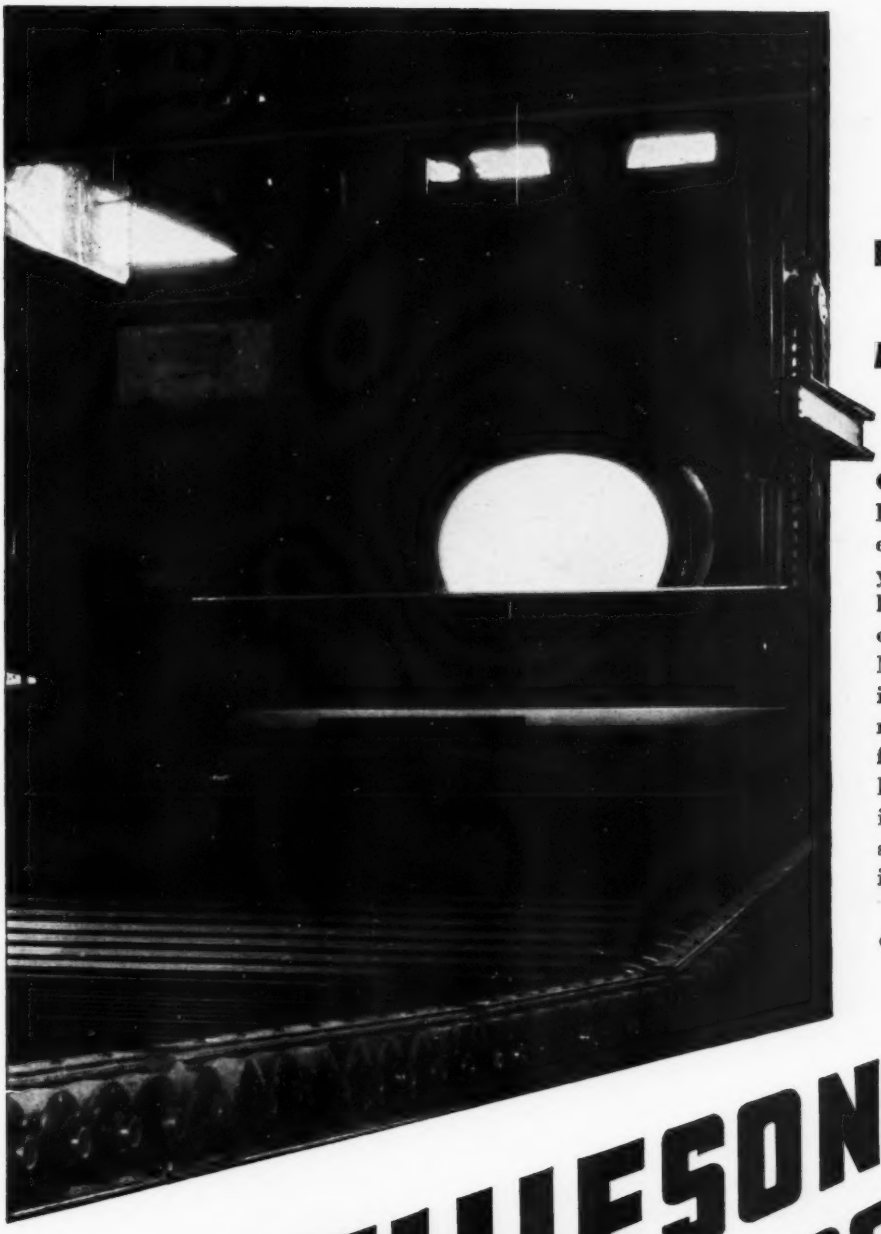

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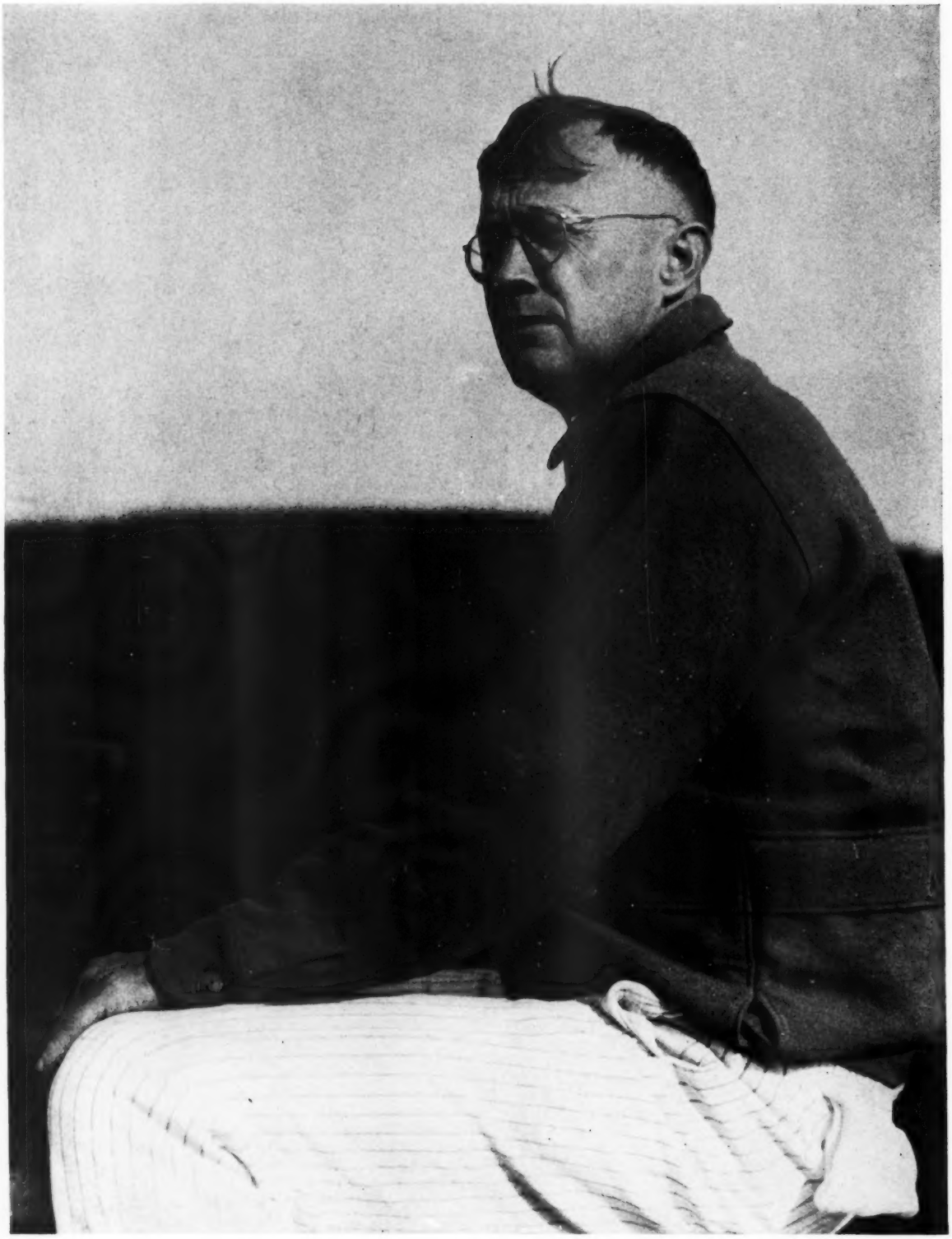
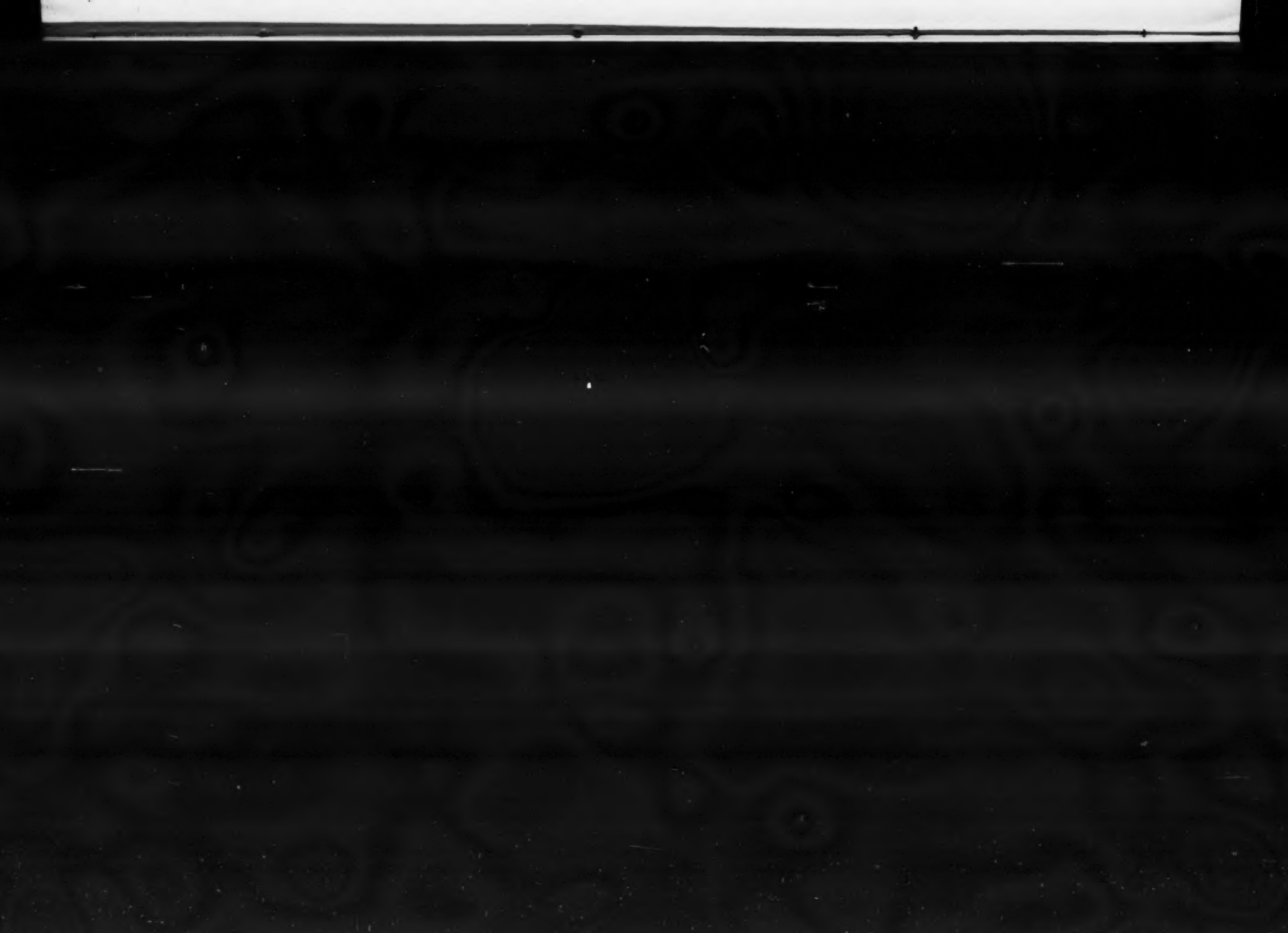


J. T. LITTLETON
Skipper of the "Co-Ed"* and host to the Glass Division at its annual summer meeting.

*She uses so much paint.



THE GLASS INDUSTRY

VOLUME 15, NUMBER 9. OCTOBER, 1934

CHEMICAL DURABILITY OF GLASS

THEME OF ANNUAL GLASS DIVISION MEETING

Program of Research Initiated by Large and Enthusiastic Gathering Representative of Entire Glass Industry

THE Glass Division summer meeting held at Lake Keuka, New York, September 14 and 15, has been generally spoken of as the most successful ever held. More than a hundred were present. A majority of the larger companies were represented and either contributed papers or took an active part in the discussion. Many of this country's most eminent glass technologists as well as representatives from the centers of research and instruction were at the conference. Thus the deliberations can be described as authoritative and weighty in their importance, and truly a cross section of the best minds of the industry.

What might be called an international aspect was given by the presence of the guests of honor, M. Parkin, Sheffield University, England, representing Professor W. E. S. Turner, whose suggestions and recommendations were most helpful.

This year's meeting differed from any of its predecessors in that a formal program had been arranged. Hitherto the purpose of these meetings has been largely social and the discussions more or less spontaneous. However, earlier attempts of the Division to deal with Durability of Glass had developed the belief by many that opinion was too divergent and the subject too controversial to rely upon informal discussion if real progress was to be made.

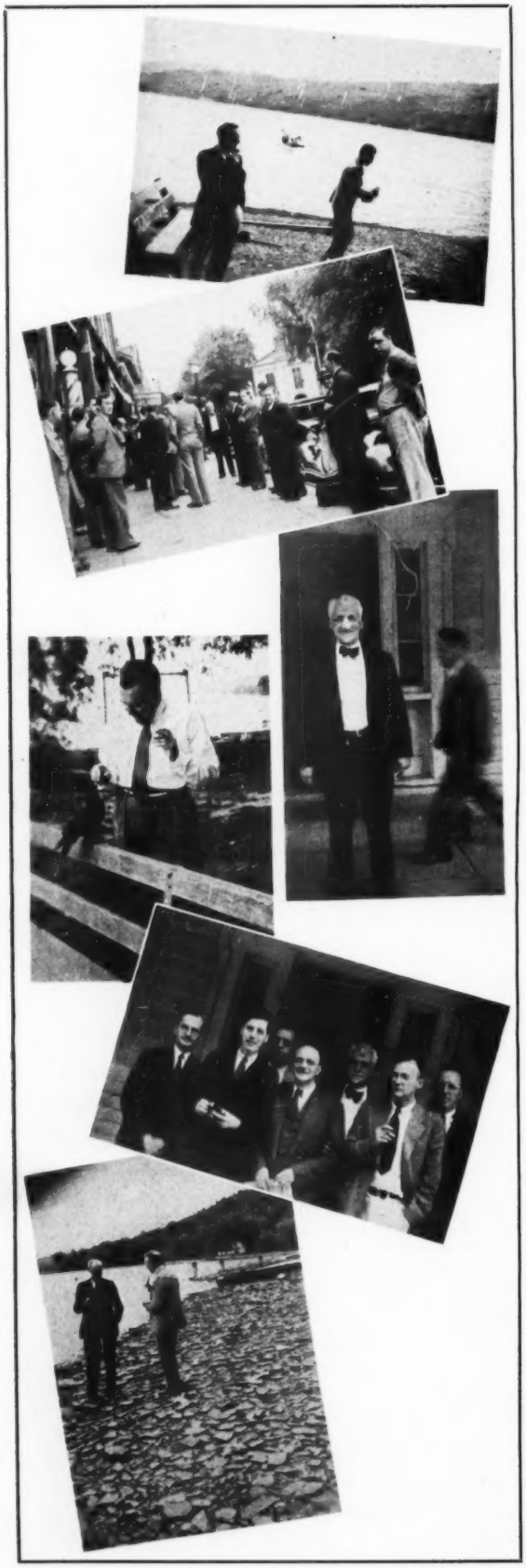
SYMPOSIUM ON CHEMICAL DURABILITY AND CORROSION RESISTANCE OF GLASS

Friday morning 9:30 (At Hammondsport)
Part I—"The Corrosion of Glass as a Problem in its Manufacture, Distribution and Service."
Flat Glass: W. F. Brown, Libbey-Owens-Ford Glass Company
Glass Containers: F. C. Flint, Hazel-Atlas Glass Company
Miscellaneous Glass Products: W. C. Taylor, Corning Glass Works
Part II—"Methods of Determining the Chemical Durability of Glass."
Chemical Durability of Glass and Methods for its Measurement: G. W. Morey, Geophysical Laboratory
The Time Factor in Tests of the Chemical Durability of Glass: D. E. Sharp, Bailey & Sharp Co.
Friday Afternoon 2:30 (At Hammondsport)
The Measurement of the Chemical Durability of Flat Glass: J. S. Gregorius, Pittsburgh Plate Glass Company (Paper read by Mr. Mahaffey)
Methods for Determining the Chemical Durability of Soda-Lime Glasses: O. G. Burch, Owens-Illinois Glass Company
Methods for Determining Special Types of Chemical Durability: Dr. M. E. Nordberg, Corning.
Surface Electrical Properties of Glass in Relation to Chemical Durability: E. M. Guyer, Corning.
Friday Evening 7:30 (At Hammondsport)
Ancient Glass Melting Practices: Dr. H. Maurach, Secretary of the Deutsche Glastechnische Gesellshaft (Paper read by Dr. S. Scholes)
Saturday Morning 9:30 (At Keuka)
A Proposed Standard Test for the Determination of the Chemical Durability of Glass: Prof. W.E.S. Turner, University of Sheffield, Sheffield, England (Paper presented by Dr. Michael Parkin).
Chemical Durability of Glass Bottles: Prof. W.E.S. Turner, University of Sheffield, Sheffield, England.
Summary and Future Program: J. C. Hostetter, Corning Glass Works
Saturday Afternoon 2:00 to 2:30 (At Keuka)
The Chemistry of Wines: F. M. Champlin
Visits to Pleasant Valley and Urbana Wine Cellars
7:00 P. M. Shore Dinner at Willow Point

The lion's share of credit for this success belongs to J. T. Littleton, Corning Glass Works, the "managing host" of the meeting as Ross Purdy aptly introduced him. Dr. Littleton's summer-camp was the *locus operandi*, and his arrangements for the comfort and convenience of his guests fell little short of perfection. What more delightful setting for a meeting than a cluster of camp cottages lodged on the shore of one of New York's most beautiful lakes, with pine needle floor and forest roof!

Boating, fishing, swimming—both indoor and outdoor sports—gave the needed relaxation between days of serious discussion. Or perhaps it was the pure ozone of this Finger Lake region that proved so generally stimulating.

Friday the Division members motored two miles to Hammondsport, where meetings were held in the Town Hall, given over to them by the Hammondsport Chamber of Commerce.



Lunch and dinner were served at the Hammondsport Hotel. Saturday meetings were held at the Keuka Lake Hotel, a few miles distant, after which the convention inspected the celebrated Urbana Pleasant Valley wineries.

As an indication of the widespread interest in the subject of glass durability outside of the industry itself, technical representatives of the beverage, milk and drug industries were present and took part in the discussion. These were: J. H. Toulouse, American Bottlers of Carbonated Beverages; H. A. Trebler, International Milk Dealers Association; and J. P. Snyder, American Druggists Association.

The program of the meeting, detailed on this page, reflects a great deal of work on the part of U. E. Bowes of the Owens-Illinois Glass Company, who was in charge of the program of technical papers. Abstracts of these papers are given on succeeding pages.

Summarizing the discussion, the first very important accomplishment was that the glass industry for the first time definitely came to grips with durability, a factor of its usefulness and as yet incapable of being satisfactorily measured in the laboratory. Up to this time merely to define the problem has been found difficult; future work can state it clearly as the "Chemical Durability of Glass."

Papers were read discussing phases of packing, shipping and storage of different types of glass, in which it was brought out that the factors leading to surface disintegration may be conveniently classified as those of manufacture, distribution and service. Further, that the results of decomposition may be (1) of appearance only, sometimes (as with optical glass) affecting the utility of the product, and again causing no impairment to its service; (2) deleterious to the product, as by causing precipitation, or change of color; (3) mechanical in effect, as by reducing resistance to thermal shock, or the bore of a thermometer restricting the flow of mercury, or reducing the wall thickness of a gauge glass.

Methods of testing durability may be of two types: (1) those relating to the surface only, and (2) those relating to the glass as glass. In establishing a program of research, the second of these methods would be used by the Division, and the surface problem be considered later. The various methods of testing offer several approaches to the problem, and the Division must next select one of them. In order that all laboratories will get comparable results, the technique of testing must be very exact. Accelerated tests might be unreliable. Some method of uniformly designating results would also be needed.

A project of this kind should be sponsored by the standards committee of the American Ceramic Society, and the cooperation solicited of the Bureau of Standards.

It was emphasized that the program does not attempt to cover specifications for glass.

Abstracts of the papers read at the meeting follow:

Exclusive and hitherto unpublished views of the Glass Division at labor. (Reading down from the top): Chief W. Keith McAfee looks the situation over. (2) Siesta. A group snapped during the noon recess at Hammondsport (Mr. Roche seems to be thinking about Bromo Seltzer bottles). (3) Ross Purdy, just after he had left a glass manufacturer whom he had tried to sell a membership. (4) Even the birds eat out of Don Sharp's hands. (5)Our genial chairman, Mr. Bailey, surrounded by his brain trust. (6) Sam Scholes and Doc. Tillotson examine Lake Keuka sand deposits for clues to the cause of weathering.

Flat Glass:

By W. F. Brown, Libbey-Owens-Ford Glass Co.

The durability of modern flat glasses is such that when glazed in ordinary windows there is no deterioration in service.

Differences between ordinary glazing and double or multiple glazing, are explained. Double glazed windows are required in air-conditioning. Glass for double glazing should have suitable durability.

"Staining" of flat glass is described. Moisture is shown to be the cause of "stain." Properly made and properly packed window glass is warehoused satisfactorily. The storage of large plates of glass is discussed.

Information is given about surface treatments and conditions, and alkalinities of surfaces. Differences between temporary and permanent impairments of surface are pointed out.

Reference is made to effect of composition on durability.

●

Glass Containers:

By F. C. Flint, Hazel-Atlas Glass Company

The durability of glass for containers should be divided into manufacture, distribution, and service problems.

The manufacturing problem is one of management, and not necessarily a problem for testing. As an example, the old problem of sulphur bloom in lehrs has been pretty well cleared up with better equipment.

The problem of distribution is limited to weathering due to moisture, carbon dioxide, and temperature fluctuations, and to the type of storage in which the influence of hydroscopic paper might hasten the other effects.

The service problem calls for glass capable of holding all classes of commodities, foods, pharmaceuticals, etc. The food problem is a minor one. There are a few very special occasions which arise, but food containers do not present any problems worth noting, most problems being in pharmaceutical lines in which the contents of the containers are approaching special materials which ought to be packed in special glass.

●

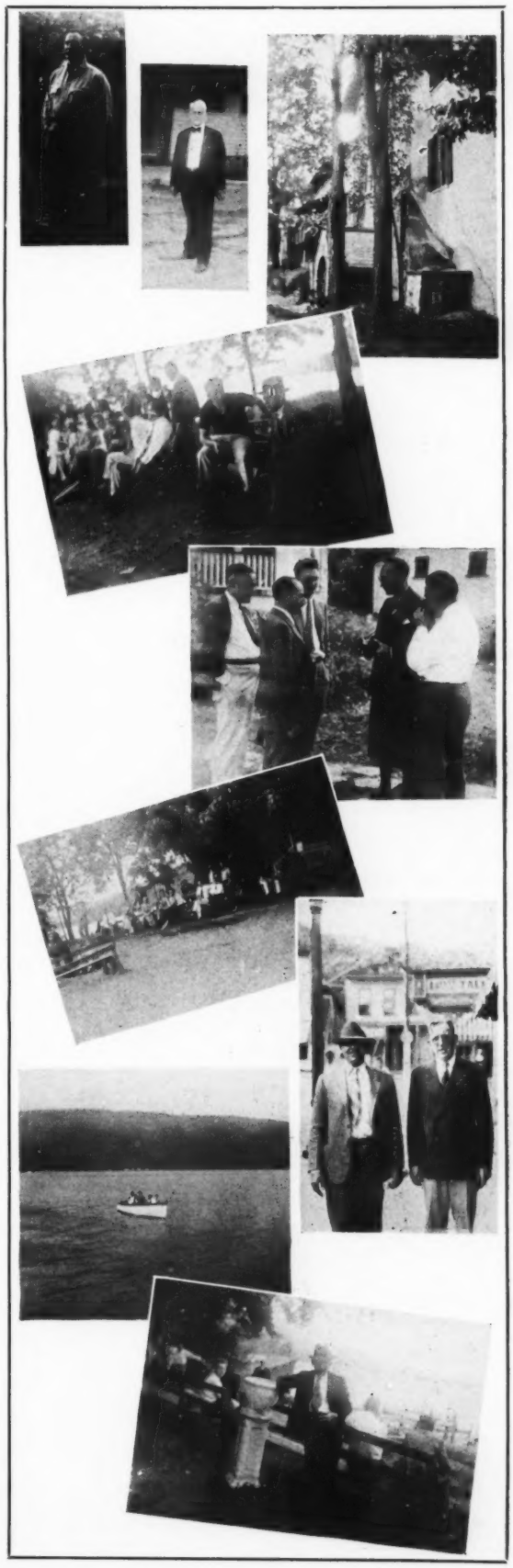
The Corrosion of Glass as a Problem in Its Manufacture, Distribution, and Service:

By W. C. Taylor, Corning Glass Works

Weathering, corrosion, or solubility is a problem existing to some extent in nearly every class of glass manufacture. It may take several forms such as:

I—Clouding or dimming of the surface caused by moist air, plus perhaps CO_2 and SO_2. This chiefly affects appearance and may be a problem in window glass, optical glass, crystal ware, etc.

II—Corrosion of the surface due to excessive or repeated exposure to moisture. This may not only affect appearance, but also the strength, as in bulbs; the



(Reading from top to bottom): (1) F. C. Flint, in a characteristic pose. (2) Ross again, this time putting his best foot forward. (3) The Pleasant Valley Wineries. (4) A gentleman of the press interviews Doc Shively. (5) The official photographer persuading some of his victims to pose. (6) The clan gathers to watch some expert horseshoe pitching. (7) President McAfee and Dick Carothers in a serious moment. (8) Lake Keuka. (9) A. N. Finn supporting a piece of statuary. Note the thick fog to the right.

heat resistance, as in lamp working tubing; or the smoothness of surface, as in thermometer tubing, where a smooth surface is necessary to have free movement of mercury.

III—Solubility caused by actual solution in water, acids, alkalies, salts, or steam, and affecting, in some cases, the product in contact with the glass, and in others the length of life of the glass in service.

Types of glass were mentioned where durability must be sacrificed for special physical properties, and others where extraordinary resistance was required. For many of these types of ware special product tests already exist. For general comparative purposes, however, a suitable test is still needed.

Such a test is not easy because glass is really very durable, and an excessive length of time is required to produce measurable results with good glasses. It is therefore necessary to accelerate corrosion. All methods so far tired are subject to criticism. The principal methods in use are higher temperature, strong alkali (which may increase solubility 100 times) or exposure of a larger surface, such as by the powder method.

Different types of glass have different temperature solubility curves, and therefore a high temperature measurement may not always be extrapolated fairly to lower temperatures. Some glasses resistant to alkali are very soluble in acid, and vice versa, so an alkaline solution is not a fair method in many cases. The powder method offers the best possibility as fair comparison, but is open to some criticism. Perhaps as a result of these papers such criticisms can be met. If not, we will have to continue to have several tests on products, and perhaps these should be continued even though we adopt a standard test for glass as glass.

●

Chemical Durability of Glass and Methods for Its Measurement:

By G. W. Morey, the Geophysical Laboratory

The attack of glass by water is a decomposition which proceeds by the extraction first of the more soluble components, then of those which are less soluble, without at any time reaching an equilibrium condition or even a steady state. The term "solubility" in its quantitative aspect cannot be applied to such a problem, and there is no logical alteration in its definition which will give it a precise meaning, when applied to a decomposition reaction. At slightly elevated temperature and the resulting water pressure, some glasses and water become completely miscible, in which case the "solubility" becomes infinite. At lower temperatures the penetration of the glass by water proceeds more slowly, and is complicated by the precipitation of new and insoluble compounds. All methods of testing are measures of the rate of the complex decomposition reactions, and as such are particularly susceptible to the conditions under which the decomposition takes place. All such

(From Top to Bottom): (1) See page 204. (2) Waiting to leave for the wineries. (3) Michael Parkin getting his first impressions of America. (4) Ronald Lester, Ernie Hommel, Charlie Spencer and Lou Roche, with other luminaries in the background. (5) Greta Garbo Cottage. (6) Dr. Littleton gives his summer home town the once over.

methods are attempts to anticipate the verdict of actual service by the use of sensitive methods, and of various methods of accelerating the reaction. The results obtained may or may not parallel the results of service, because the methods used do not truly measure the rate of the decomposition reactions, but rather bear only on inferential relationship to those rates. None of them can truly give the right answer because there is none, and all must be interpreted through correlation with service. In adopting standard methods the details of experimental technique must be specified in great detail, and in the adoption of standards of minimum attack great conservatism should be used.

●

The Time Factor in Durability Tests:

By Donald E. Sharp, Bailey & Sharp Company

Chemical durability measurements are measurements of a rate of attack. If samples of a glass are subjected to any of the customary test procedures for varying lengths of time, and the measured degree of attack is plotted against time on double log paper, the curve is a straight line after a certain minimum period which evidently depends, at least in part, on the method of preparing the sample. The amount of attack, and hence the rate also, is therefore an exponential function of the time, and may best be expressed by an equation of the form:

$$Y = K + a\ t^m$$

where Y is the measure of the attack, expressed either by the loss in weight, by the alkali extracted, or by any other measurable means, such as the electrical conductivity of the solution.

The exponent m varies with the means employed for the test, and in the powder method evidently depends upon the size and shape of the particle. For any single method m is quite nearly the same for good or bad glasses, and hence the chemical durability is determined by the constants K and a.

It was shown that the parabolic function of Keppeler and Thomas was only a special case where the exponent m was equal to 0.5. Results were given on time treatment of a glass over a total period of almost 500 hours. The glass was completely disintegrated and throughout practically the entire range (after the first few hours) the amount of attack could be expressed by the above equation with an error of less than 1 per cent.

The constants in the equation all vary with temperature, and for a range from room temperature to the boiling point, the equation expresses the results satisfactorily. Above the boiling point, the equation gradually departs from a true representation of the data, and, indeed, a temperature is reached ultimately where the effects of penetration and hydration so complicate the conditions that the measuring means no longer serves as an indication of the amount of attack.

(1) The camera man caught these in(ti)mates of Jean Harlow (cottage) unaware. Note the smoke-like haze which Mr. Miller brought with him from Pittsburgh. (2) Doc Insley tells a good one to Morey and Bowes. (3) The Willows of Willow Point. (4) Some professional tossers masquerading as amateurs. (5) More Willows. (6) Babcock gazing at the statue of Napoleon. (7) Portrait of a crow. (8) Waiting for the train to Hammondsport.

Photo by Bath Photo Studios, Bath, N. Y.

THE GLASS DIVISION OF THE AMERICAN CERAMIC SOCIETY
Annual Summer Meeting, Lake Keuka, N. Y., September 1934.

The Measurement of Chemical Durability of Flat Glass:

By J. S. Gregorius, Pittsburgh Plate Glass Company (Paper read by Mr. Mahaffy)

Flat glass must resist rain, ice, snow and other atmospheric attack in use and must be delivered to the user with an unimpaired surface. Sheets of glass stored in piles with faces together may hold water which causes weathering and filming even in as short a time as 14 days. Such filming of the surface is sufficient to cause rejection.

Precautions which can be used while the glass is in storage are (1) separation of the glass sheets by sufficient space to allow air circulation, (2) introduction of absorbent material such as paper between the sheets to absorb any traces of moisture.

The filming of sheet glass is due to leaching of silicates rich in alkali from the glass by moisture, and these in turn attacking less soluble silicates.

It is therefore essential that some method of measuring the resistance of the glass to attack should be developed for use as a control method by the manufacturer. Visual examination gives a qualitative measure. The quantitative method found most useful and reproducible is the powder method. The sample is crushed and the grains passing through 40 mesh and remaining on a 60 mesh sieve are used. The sample is treated in the usual way except that after the boiling period it is divided into two aliquots. One of these is evaporated to dryness and the residue expressed as "soluble solids" in grams/m^3. The other is titrated with acid using methyl red as an indicator and expressed as grams of Na_2O/m^3.

In the above work it was found that area decreases with increasing grain size and, based on the assumption that the particles were spherical, that it could be expressed by the formula, area $= \frac{3}{100 \times r \times d}$ where r is the radius of the glass particles in mm. and d is the density of the glass in gr/cm^3. The results of a test described showed that the solubility of the finer particle sizes was approximately 50 per cent of that of the coarser sample, expressed on an area basis. The amount of attack was not found to be proportional to the area function.

●

Methods for Determining the Chemical Durability of Soda-Lime Glasses:

By O. G. Burch, Owens-Illinois Glass Company

The methods in general use for the determination of the chemical durability of soda-lime glasses are classified according to whether the sample tested is the finished glass article or a crushed glass sample of definite grain size. A method of the latter type calls for treatment of a 10 gram sample of glass grains of specified mesh size with a definite quantity of N/50 H_2SO_4 for a specified time at a definite temperature with subsequent determination of the alkali leached from the sample.

The following conclusions are drawn:

1. Soluble alkali is a more reliable measure of the weather resistance of a glass than is the total soluble material.

2. The ease with which alkali may be leached from a finished glass article depends on the size and shape of the article, its age, and the atmosphere of the lehr in which it has been annealed. It is practically impossible to compensate for these factors.

3. A powder method for determining the chemical durability of soda-lime glasses has the following advantages over a surface method as a control test:

(a) Glass in any available form may be crushed and used in such a test.

(b) A sufficient amount of alkali will be dissolved from a 10 gram sample of 30 to 40, or 40 to 50 mesh glass in a period of 3 or 4 hours at a temperature of 200°F. or slightly less to secure accurate results on any commercial soda-lime glass.

(c) A powder method is the only method giving a true measure of the durability of glass free from any modifying surface conditions.

4. In the powder test described, the concentration of sulphuric acid employed has no effect on the results obtained.

5. In the described test the amount of alkali dissolved has a definite relationship to the grain size and weight of sample used, and to the time and temperature at which the test is conducted.

●

Method of Determining Special Types of Chemical Durability:

By M. E. Nordberg, Corning Glass Works

Various methods of measuring the durability of glass are necessary when dealing with ware made from different kinds of glass and intended for different kinds of service. The tests used in our laboratory can be classified as alkali, water, and salts and vapor tests, according to the corroding medium used.

In one alkali test, polished plates of glass are immersed for 50 hours in a 5 per cent NaOH solution at 80°C. and the losses in weights determined. In a similar test the attack on the actual ware is measured when exposed to a boiling 5 per cent NaOH solution for 6 hours. Tests have also been made using various temperatures, concentrations and time periods, as well as different alkalies including Na_2CO_3. The amount of corrosion in 5 per cent NaOH is almost linear with time.

For testing chemical ware a beaker is filled with CO_2 free distilled water which is kept at 80°C. for 48 hours. The solution is then evaporated to dryness in a platinum dish and the residue weighed. In some cases water is boiled for 24 hours in a flask fitted with a reflux condenser. Another test consists of immersing polished plates in distilled water at 95°C. and determining the losses in weights. The results of this test have been found to depend on the pH^+ of the solution, a unit change in pH^+ causing, for different glasses, from 2 to 4-fold increases in the amounts of attack. Water tests have also been made in sealed tubes at various temperatures up to 260°C.

For determining the durability in acids a 5 per cent HCl solution at 95°C. is used. 20 hour tests are made, usually on polished plates. Some glasses have been found to have stabilities toward acid decidedly less than those toward water. A powder method is used for the testing of ampoule bottles. 10 gms. of powder, 40-60 mesh, are treated for 24 hours with N/.20 HCl at room temperature. The excess acid is titrated using methyl

red as an indicator. Results are expressed as per cent KOH.

Tests in salt solutions simulating sea water are used, especially on marine ware, and the results determined by visual inspection. These results do not agree with those obtained when the losses in weights of the samples are used.

In the steam test most generally used, the samples are exposed 100 hours to steam under 100 pounds pressure. The loss in weight of the sample as well as it appearance gives a measure of the corrosion. For some types of articles a lower steam pressure is used. The erosive action of the steam has much to do with the results obtained; so gauge glasses are now being tested by an actual service test. They are fitted to a boiler operating continuously at 400 pounds pressure.

For the testing of art glass the fogging produced by alternate contact with moist air (or CO_2) and dry air is determined visually. The test may be run at room temperature, or 60°C.

The relative amounts of corrosion of three types of glasses, a borosilicate glass, a lime glass, and a lead glass are found to vary considerably depending on the type of test used.

●

Relation of Electrical Surface Resistance of Glass to Chemical Durability:

By E. M. Guyer, Corning Glass Works

Surface resistance measurements on a graded soda-lime-silica series of glasses and on a mixed series including borosilicates, lead glasses, lead borosilicates and lime glasses when compared with measurements of loss of weight in water vapor made on the same glasses indicate:

1. That surface resistance measurements are closely related to surface durability in the presence of water vapor in lime glasses when comparisons are not sought between glasses of absolutely different types.

2. That glasses of widely different types cannot safely be compared without studying the behavior of a graded series of samples with systematically varied composition about each type.

3. That the very early stages of moisture film formation on previously dry glass seems to give surface resistance data in closer correlation with durability towards water vapor than later stages when the film is thicker.

●

Ancient Glass Melting Practices:

By H. Maurach, Deutsche Glastechnische Gesellshaft. (Paper read by S. M. Scholes)

After the dinner Friday, Dr. S. M. Scholes read a paper by H. Maurach, Secretary of the Deutsche Glastechnische Gesellshaft, on "Ancient Glass Melting Practices." The talk was illustrated by slides and was instructive as well as interesting.

●

The Chemical Durability of Glass; A Plea for A Standard Method of Test:

By Prof. W. E. S. Turner, University of Sheffield, Sheffield, England (Paper read by M. Parkin)

As a result of experience extending over many years the author considered that in order to determine the durability of glass as glass, some form of the powder test was to be preferred to any other. At the same time he recognized that other tests might be desirable and even necessary from the point of view of the manufacturer and purchaser, though even here the powder method serves as a criterion of the durability of vessels into which the glass might be made.

The Standards Committees of the Sheffield and German Societies of Glass Technology had for some time past been cooperating in an attempt to correlate results obtained using their respective powder methods. From this it appeared that both were capable of giving reasonably consistent results. It was suggested that if other countries than England and Germany could adopt the powder method as a general standard method, the necessary work in reconciling the various views as to procedure could best be left to a small committee drawn from those having practical acquaintance with the subject.

●

The Testing of Glass Containers for Chemical Durability:

By Professor W. E. S. Turner, University of Sheffield, Sheffield, England (Read by F. C. Flint)

This paper discusses some of the more fundamental conditions which must be understood in connection with the testing of glass containers, grouped into three main sections, namely, (1) conditions in tests which seek to measure durability by alkali extraction, (2) referring to the breaking down of glass by pitting, flaking and cracking, (3) the special case of alcoholic preparations.

In part one, the effect of lehr gases, the agreement of results of tests on the same bottles tested in different laboratories, the effect of length of time of testing, effect of length of time of storage before testing, effect of ratio of area to volume, and the effect of size of the container were discussed, and data given. It was shown that all these factors affected the results, and that a complete test must consist of (1) the analysis of the glass, (2) a durability test by the powder method, (3) a test on a glass container of standard size and shape.

In the second part of the paper the factors associated with pitting and flaking of the surface were discussed. It was shown that pitting is usually the result of mechanical injury which is later developed by chemical action into pits, etc. Flaking is a more involved action which did not seem to depend entirely upon the chemical durability of the glass.

In the third part it was shown that aqueous solutions of alcohol are more corrosive than water, and that the most severe action occurs at a concentration of 40 per cent alcohol.

●

Consumer's Viewpoint:

Among those present by invitation were Dr. J. Toulouse, representing the Association of American Bottlers of Carbonated Beverages; Dr. Trebler, representing the International Milk Dealers Association; and Dr. Snyder, representing the American Druggists Association. At the close of the Friday afternoon session, each of these men gave a brief summary of various troubles which they have experienced from chemical corrosion of the glass containers coming under their observation. They presented the problem from the consumer's standpoint.

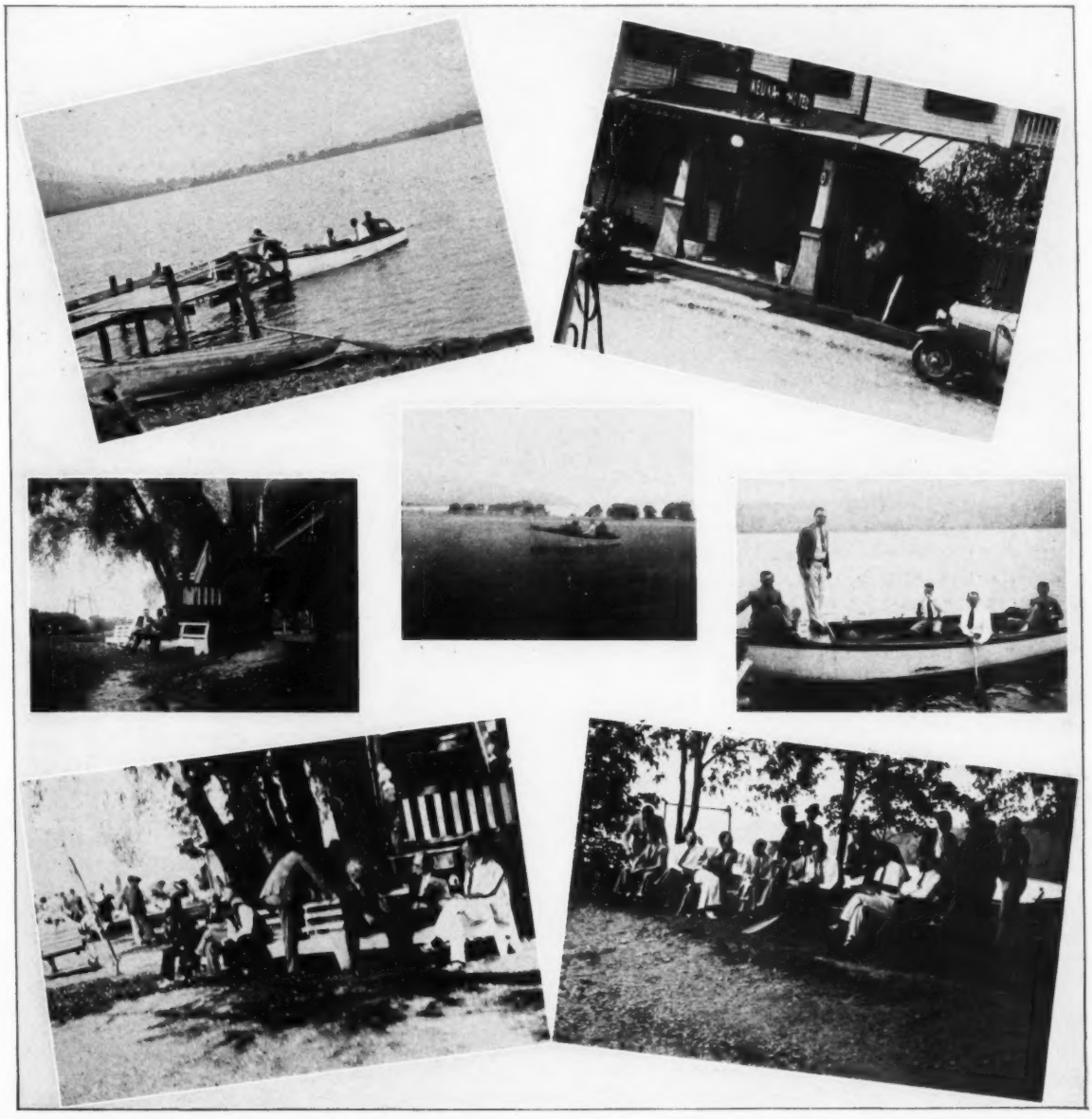
During the discussion which followed, it was shown that many of the practices which are particularly destructive to bottles, such as the use of highly alkaline washing solutions, are specified by law. Much work has been done in this connection on the washing and sterilizing of milk bottles, but no entirely satisfactory neutral washing solution has thus far been developed.

Their representation of the problem of chemical durability of glass from the consumer's standpoint confirmed the necessity for the development of some standard methods for testing chemical durability which may be used both by the manufacturer and the consumer as a means for assuring that the correct product is purchased for the specified use.

The Chemistry of Wines:

By F. M. Champlin

F. M. Champlin showed that little was known about the fermentation of grapes for wine until Pasteur. The progress of fermentation was followed by tables showing the change in the alcoholic contents during fermentation. The development of the glycerine, succinic acid and small quantities of the higher alcohols and compound esters, accompanied by the reduction in the acid content, is largely responsible for the flavor and bouquet of the various types of wines in their later stages, although considerable of the individuality is derived from mineral matter in the original grape.



A group of snap shots taken by Glass Industry Staff photographers. We call particular attention to the center picture of a group of hardy mariners marooned homeward bound from the wineries. The Glass Industry wishes to express its thanks to the following gentlemen for their contributions to our rotogravure pages: Hobart N. Kraner, Kraner-Corhart Photographic Studios; Jack H. Waggoner, Mellon Photo Shoppe; Ernest M. Hommel, Glasscolor Features, Inc.; E. L. Hettinger, Willson, That's All; and C. D. Spencer, General Electro-Magnetic Pictures.

ANALYSIS OF CERIUM OXIDE IN GLASSES

AS the last few years have shown a large increase in the use of cerium salts in the manufacture of colored glasses, and since fairly large amounts of cerium must be used in the batch in order to obtain the desired coloration, the determination of the cerium oxide content of such glasses has become necessary.

Cerium is a member of the third analytical group, being precipitated along with Al, Fe, Zr, Ti, etc., by ammonium hydroxide. Cerium can be separated from the members of this group and from other common metal bases by means of oxalic acid added to the slightly acid solution. As the other members of the rare earth group are also precipitated by oxalic acid it is not possible to isolate the cerium by this single procedure. It is fortunate, however, that the cerium compounds used in glass making are in most cases the pure oxide or oxalate, and not the so-called commercial cerium oxide which is a mixture of the rare earth oxides and contains a variable percentage of cerium oxide. It is not necessary, therefore, in the case of ordinary glasses, to attempt the difficut separation of cerium from the other rare earths. Small amounts of thorium may be present as an impurity in the cerium compound, but the amount is usually so small that it is not necessary to carry out the separation.

In the analysis of cerium containing glasses the usual sodium carbonate fusion and silica separation with hydrochloride acid is made. The ammonium hydroxide precipitate must however, be re-precipitated. The cerium is then obtained as follows: The ammonium hydroxide precipitate is dissolved in hydrochloric acid and evaporated to dryness. Take up with water, and add hydrochloric acid until the acidity is equivalent to 0.3N. Treat with an excess of a saturated solution of oxalic acid, sufficient to leave 3 grams of oxalic acid per 100 cc. of final solution. Allow the solution to stand at 60°C. for 12 hours, or preferably overnight. Filter off the precipitate and wash thoroughly with hot, slightly acidified water.

If aluminum and iron greatly exceed the cerium content it is better to treat the ammonia precipitate with hydrofluoric acid, and evaporate nearly to dryness. Take up with water and a little hydrofluoric acid. Digest for a short time, filter and wash with water containing a little hydrofluoric acid. Sluice into a platinum dish, ignite the filter, and add the ash to the platinum dish. Evaporate with sulphuric acid, expelling the excess over a radiator, take up with water, and precipitate the cerium with oxalic acid as shown above.

If the cerium is known to be free of the other rare earths the oxalate precipitate may be dried, and ignited at 1200°C. and weighed as the oxide (CeO_2). Non-volatile alkaline salts will cause high results if the cerium oxalate has not been well washed. If the cerium is associated with the rare earths it is possible to determine the cerium content of the oxalate precipitate by the following volumetric method which does not require the separation of the other rare earths:

The oxalate precipitate and paper are ignited with a blast lamp in a platinum crucible to the oxide in the ordinary way; the oxides are next warmed with 10 cc. of concentrated H_2SO_4 until decomposition is complete, allowed to cool, and then carefully poured into 100 cc. of ice-cold water. This procedure should result in complete solution; if not, add 10 cc. more of concentrated H_2SO_4 and heat on a hot plate until a clear yellow solution is obtained. This solution is then brought back to approximately 100 cc. volume, 2 grams of ammonium sulphate and 1 gram of sodium bismuthate added, heated to boiling, cooled, filtered through a Gooch crucible, and washed with 100 to 150 cc. of 2 per cent H_2SO_4. To this solution is then added an excess of standard N/40 ferrous sulphate solution—color change yellow to colorless—and the excess is titrated back with a standard permanganate N/40 solution. From the burette reading calculate the percentage of cerium so that:

$$10Fe = 10CeO_2, \text{ or } 1Fe = 1Ce$$

$$1 \text{ cc. } N/40\ (NH_4)_2Fe\ (SO_4)_2 \cdot 6H_2O = 0.004306 \text{ gr. } CeO_2$$

$$\frac{172.25}{1000 \times 40}$$

Besides decomposing the oxalate precipitate as above directed, the oxalate can be washed off the filter paper with hot water and converting the hydroxides by boiling with NaOH. The precipitate formed is filtered off, washed well with hot water, and dissolved through the filter by means of dilute H_2SO_4. The filtrate is made up to 100 cc. and enough H_2SO_4 added to bring the amount up to 20 grams of concentrated H_2SO_4 and treated with ammonium sulphate and sodium bismuthate, and finished as directed.

If the precipitated oxalate is small, it can be decomposed by heating with 20 cc. of concentrated H_2SO_4, and finished in the usual manner.

SAFETY GLASS OBLIGATORY

The use of safety glass in schoolbuses and in all vehicles operated for hire, manufactured after Jan. 1, 1935, will be obligatory in Iowa, according to an opinion just rendered by Assistant Attorney General Harry Garrett at Des Moines. The new Iowa law, passed by a special session of the Iowa legislature last winter, becomes effective on Jan. 1, 1935.

The new statute also provides that after July 1, 1935, it will be unlawful to operate all other cars regardless of whether or not they are used for hire, the statute providing for vehicles manufactured and sold after that date. Equipment bought and manufactured prior to that date need not be equipped with the glass to come under the law.

SOVIET GLASS ENGINEERS VISIT U. S.

Alexander Antonof and Alexander Wasilieff, have recently come to this country from the glass industry headquarters, U.S.S.R., located at Moscow. Starting from New York, the two engineers will visit many of the glass making centers in the east and middle west. They are particularly interested in glass making machinery.

FUEL OIL—ITS TYPES, PROPERTIES AND SPECIFICATIONS

FUEL oil has often been defined as "any petroleum product used for the generation of heat in a fire box." In the last few years, however, the term has been used to describe only certain definite petroleum products. In the early days of the petroleum industry, crude oils, topped crudes (i. e., crudes from which only the lightest, low-boiling, and most easily removable fractions have been separated) or weathered crudes (crudes which have lost their volatile fractions through storage) were often used for fuel purposes. The increasing importance of gasoline and lubricating oils, in addition to the development of cracking methods which have increased the yield of these valuable products, has led to the discontinuation of these sources of fuel oil. Today there are three general classes of petroleum products that come under the term fuel oil: (1) distillate oils, (2) residual oils, (3) blended oils.

Distillate oils consist of the oil fractions distilled intermediate between kerosene and lubricating oils. As they are products of a distillation process they are relatively free from tarry substances, sediment or salt. They possess comparatively low flash and fire points, in addition to a low viscosity. Distillate fuel oils may vary in gravity from 43°Be (crude kerosene), through gas oils (approximately 35°Be), and the light fuel oils of 28 to 32°Be, to what may be classified as a medium fuel oil (20 to 25°Be), depending upon the source and treatment of the original crude.

Residual fuel oils may be either topped heavy crudes or the viscous residual products obtained from the crude oil after the removal of the valuable, more volatile hydrocarbons by cracking processes or straight distillation. This type of fuel oil is low in gravity (10 to 15°Be), and is very viscous. The flash and fire points are usually very high, due to the removal of the volatile materials. This factor makes for safety in handling and burning this type of oil. Being obtained as the product of distillation they are water free, any water present being due to leakage, etc.

Blended fuels are mixtures of the above two classes of oil. As the residual fuel oils are often too viscous for successful use they are blended with the lighter and more fluid distillate oils.

The important properties of oil fuels for industrial use are: (1) specific gravity, (2) heating value, (3) flash point, (4) pour point, (5) viscosity, (6) water and sediment, (7) sulphur content. The testing of these fuel oil properties is of little value unless the specifications for the individual oil are given. General specifications cannot be used to advantage due to the wide difference in conditions of use. There are, however, certain points that should always be borne in mind when drawing up oil contracts. These points are taken up in the following discussion.

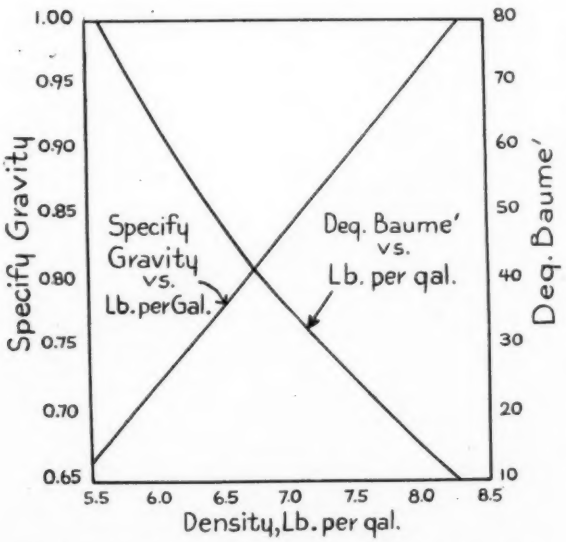


Fig. 1. Comparison of density in pounds per gallon, degrees Baumé, and specific gravity.

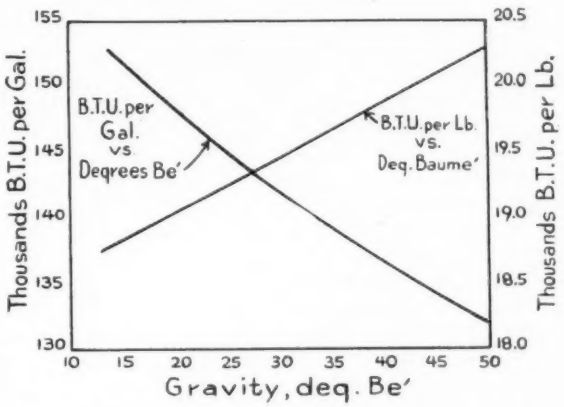


Fig. 2. Approximate heating values of gravity fuel oils.

Fuel oil is nearly always sold on a volume basis, and not by weight. Accurate determinations of its specific gravity are therefore essential. As the gravity varies with temperature the volume is usually calculated to a 60°F. basis. All gravity determinations must accordingly be calculated to the gravity at 60°F. Fig. 1 shows the density of oils in pounds per gallon plotted against specific gravity and degrees Baume. It is an erroneous assumption that the gravity of an oil gives an indication of its volatility or its viscosity. There is no natural relationship between these two properties and the gravity. A knowledge of the gravity, however, permits the B. T. U. value to be calculated with good accuracy.

The heating value of fuel oils ranges between 18,000 and 20,000 B. T. U. per pound, 18,500 being an average value. Oils of low degree Baume, while possessing a lower heat value per pound than oils of high degree Baume, have a higher heat value when considered on a volume basis. This difference, weight—volume heating value is illustrated in Fig. 2. The heating value of fuel oil may be determined by the usual calorimetric methods, or calculated from the gravity by the following formula:

B.T.U. per lb. = 18,650 x 40 (Be—10)

Example: gravity of oil = 15°Be

B.T.U. per lb. = 18,650 x 40 (15—10)

" " " = 18,850

The flash point of an oil is defined as the temperature at which sufficient vapor is given off under certain conditions to form a momentary flash when a small free flame is brought near its surface. As this temperature varies with the apparatus and procedure employed, a standard method and apparatus is used for its determination. The lower the flash point the easier it is to ignite the oil, but the fire hazard of the oil increased. The flash point is prescribed by law in nearly all of the States, being set at a minimum of 150°F.

The pour point of an oil is the lowest temperature at which it will flow under prescribed conditions. A determination of the pour point is important in localities where low temperatures are encountered, as it gives an indication of the degree of flow of the unheated oil.

The viscosity of an oil is a measure of its resistance to flow. It is measured by noting the time required for a definite amount of the oil to pass through an orifice under known conditions of temperature and head. The determination is usually made at a temperature of 122°F., although two determinations at different temperatures are sometimes made. The data is then plotted on a straight line temperature-viscosity chart. A straight line drawn through these two points may then be projected to indicate the proper burner temperature for the oil, in addition to determining the temperature at which the oil will flow freely to the pump suctions.

Water and sediment are found in nearly all fuel oils. The water is due mainly to contamination from leaky heating coils, condensation, or rain. The sediment may consist of carbon or carbonaceous material due to cracking, rust from the pipe lines, or mineral matter from the original crude. Excessive water content may cause trouble in burning, while the sediment will cause clogging of the burners or pipe lines unless removed by straining devices or, in some cases, by centrifugal methods.

Excessive sulphur content in a fuel oil is objectionable due to the action of the sulphur dioxide formed during burning on the material being heated, or on the refractory brickwork. High sulphur fuels may also cause corrosion of the storage tanks or the pipe line.

As has been pointed out, it is unpractical to draw up general specifications that will embrace all fuel oils. A standard set of specifications have been drawn up, however, by a group of interests associated with fuel oil, and have been adopted as commercial standards.

The requirements for industrial fuel oils are shown in Table 1. (Taken from Commercial Standards CS12-29.) With these specifications as a starting point the glass manufacturer using oil fuel may draw up his own specifications based on the actual conditions under which the oil is used.

Table I.

Grade of Oil	Flash Point (Min.)	Water & Sediment (Max.)	Pour Point (Min.)	Viscosity (Max.)
No. 4, Light....	150°F.	1%	15°F.	125 sec.[2]
No. 5, Medium.	150°F.	1%	15°F.	100 sec.[3]
No. 6, Heavy....	150°F.	[1]	15°F.	300 sec.[3]

[1] *Sediment not over* 0.25 *per cent; total water plus sediment shall not exceed* 2.0 *per cent.*

[2] *Saybolt universal at* 100°*F.*

[3] *Saybolt Furol at* 122°*F.*

SHIMADA HERE FROM JAPAN

S. Shimada, of the Shimada Glass Works, Osaka, Japan, has been visiting the glass industry of the United States the past month. The Shimada company manufactures large quantities of tumblers and tableware, and one of the objects of Mr. Shimada's visit has been to purchase new machinery for his factory. He is now at Vancouver and will sail shortly for home.

PLATE GLASS PRODUCTION

Total production of Polished Plate Glass by the member companies of the Plate Glass Manufacturers of America for the month of August 1934 was 7,449,906 sq. ft., as compared to 7,241,867 sq. ft. produced by the same companies in the preceding month, July 1934, and 11,326,618 sq. ft. produced by the Association members in the corresponding month last year, August 1933.

This makes a total of 62,581,044 sq. ft. produced by these companies during the first eight months of 1934, as compared to 60,803,359 sq. ft. produced by the Association members during the first eight months of 1933.

LIQUOR BOTTLE REGULATIONS TO FACE COURT TEST

The legality and propriety of the Treasury's regulations on liquor bottles, particularly insofar as they relate to prohibition against re-use of the containers, has been placed before the Supreme Court of the District of Columbia in a suit brought by a bottle jobber to restrain enforcement.

The action was instituted by the Buffalo Bottle Co., 401 New Jersey Avenue, N. W., Washington, D. C., in behalf of that Company "and all others similarly situated." The court was asked to issue a temporary injunction pending a more thorough inquiry, and then to permanently enjoin the Treasury Department from carrying out its bottle control program. Secretary Henry G. Morgenthau, Jr., was given 20 days to file his answer, but it is expected that he will ask, and will be granted, further extensions.

The Act of Congress under which the regulations were promulgated permits "reasonable regulations on size, branding, marking, sale, re-sale, possession, use and re-use" of bottles for liquor, but does not attempt to regulate industrial uses of bottles, the complainant points out; but, he avers, the requirements announced by the Treasury are "oppressive, arbitrary, unreasonable and discriminatory. The said regulations do not regulate, but prohibit."

The propriety of the regulations is challenged on the ground that they will, if permitted to be invoked, exclude from business the petitioning company and all others in the same line of business. It is argued that bottle jobbers cannot continue to operate if not allowed to engage in the sale of used liquor containers, and for that reason unemployment will be increased and invested capital destroyed.

The plaintiffs have been jobbers in new and used bottles for 30 years, engaging principally in the reclamation of used bottles. Included are used liquor bottles intended, according to the bill of complaint, for use as containers for floor oil, vinegar, ammonia, fluid polishes, shellac, liquid shoe polish and flavoring extracts.

DECORATED GLASS

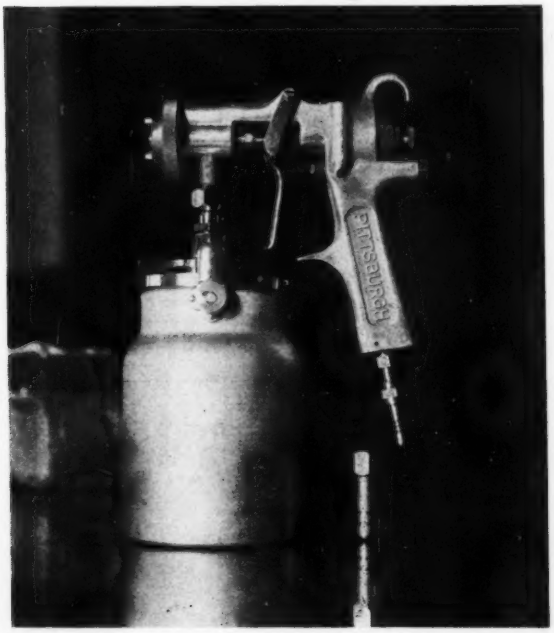
By E. M. HOMMEL

GLASS may be decorated by means of painting, cutting, engraving, etching, or chipping methods. Due to the present day demand for color the decorating of glass by machine has become one of the most important methods of glass decoration.

While a few low-cost glass articles are still decorated with oil paints the majority of glass ware is ornamented with either transparent or opaque vitrifiable colors which are fired on to the surface of the glass. The manufacture of these vitrifiable colors is a highly developed art. Not only must the color be pure so that it will be true and clean after firing and not burn out during the firing, but the physical properties of the color must be such that it will melt and fuse to the glass at a temperature lower than that at which the glass itself will soften. The expansion coefficient of the color must be close to that of the glass so that it will not chip off or craze. The chemical resistance of the color must be such that it will resist repeated washings in water or the mild alkalies such as are used for cleaning glassware.

The medium used to carry the color is just as important as the color itself. The medium must flow enough to carry the color, but it must not run when placed on the glass. When fired, it must volatilize before the color matures, otherwise blistering will result. After firing, the medium must not leave a visible residue of carbon.

The placing of the color on the glass may be carried out by several different methods depending upon the nature of the decoration. Glassware decorated with individual designs requires the creative ability of skilled artists. This type of decoration, being handwork, requires the use of innumerable size and shape brushes. For example, a brush different from that required for painting flowers is used for line work. Where the glass surfaces to be decorated are rough with depressions, a stiff brush is needed to work in the color.



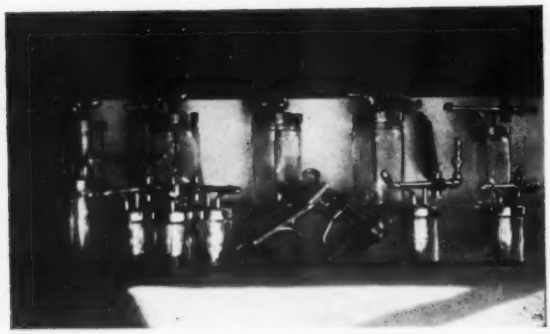
A Pistol Spray Gun.

The four specimens on the right are printed from steel plate. On the left, rubber stamping. Black glasses are banding specimens.

The staining of glass windows requires both a special brush and a special method for applying the color. Here the color is stippled, or roughly dabbed on, and a stippling brush is used. Since these decorations are generally viewed from a considerable distance, this work requires a different application of color and the stippling method is the most effective way to achieve it. The difference in doing this work and the ordinary decorating of small pieces is much like the difference in stroke between an oil painting for an ordinary room and a large mural.

In the commercial production of standardized designs, or the painting of the entire glass surface, the color is applied to the glass by means of mechanical methods such as spraying, squeegee, printing, or stamping. In spraying, either the entire surface may be sprayed, or a stencil design may be cut and the color sprayed through. In order to be able to use a spraying machine efficiently the medium in which the color is suspended must be easily sprayed, but must not run after it is applied to the glass. The machine itself must atomize the material perfectly so that fine particles are broken up and appear in the proper mechanical state on the object. Prior to adoption of spraying machines, large surfaces were decorated by applying a "binder," and then rubbing in the colors with a wad. This method, however, caused the different colors to become smeared. By spraying the colors on, it is possible to blend them and keep them clear.

The squeegee method is the most recent and unique development in the art of glass decorating. It is entirely revolutionary. The process takes its name from the rubber squeegee used to dry show windows. In squeegeeing, a fine silk screen is prepared on which the design to be made is blocked out. The blocking out is done with a specially prepared shellac-paper which is melted into the screen. The screen is then fitted into a frame which holds the color and which in turn fits over the article to be decorated. After the screen and the



SPRAYING MACHINES
Jar sprays, a curved sprayer for work on interiors, and (center) a pistol spraying machine.

frame are placed over the object, the rubber squeegee is rubbed over the screen and forces the color through. In order to make this process successful, the proper medium to carry the color had to be developed. Since a fine count silk is used for the screen, the oil must go through it readily, and carry the color but not clog the screen. Once on the glass, the design must not blur or run, the mesh marks of the silk must disappear, and, in the firing, the oil must not cause boiling or blistering. The squeegee can be run by machinery and permits decorating to be done at a small fraction of the cost of all former processes. It is successfully being used for the application of brand-marks on gasoline signs, milk bottles, and many different types of glass containers.

The printing of colored designs on glass is accomplished in the following manner. A plate of polished copper, steel, or even heavy plate glass, is covered with an acid resisting material. The design to be used is cut through the resist, and the plate placed in acid to "eat" out the design. The plate is cleaned and the design recess filled in with color mixed with medium. Afterwards a special type of thin tissue paper is pressed hard against the plate and the vacuum created lifts the design to the paper, and is then transferred to the glass.

Printing with a rubber stamp can be done on glass just as it is done on paper, except, of course, that color mixed with oil is used and not ink. While this is a quick and economical method it is not entirely satisfactory, as the finished work is not well defined.

Gasoline signs decorated by squeegee. In the foreground is gold encrusted ware, vases hand decorated.

Although the use of mechanical methods of applying the color do much to prevent unsatisfactory results it is also necessary to exert the greatest of care throughout the entire procedure. For example, ware that is to be decorated must not be subjected to excessive manual handling, as the finger prints of some people will show through the colors and will, of course, spoil the work. Glass that is moved from a cold to a warm room will form moisture on its surface, and will cause trouble in the coloring operation. Often where the finished article is to be used before a light it is necessary to place a light behind the piece while the color is being placed, so as to insure the correct effect. Needless to say, the operation of the decorating lehr must be under the strictest control to prevent the development of broken or out of shape articles.

INDIUM GLASS*

The addition of indium sesquioxide to a glass mixture containing sulfur colors the glass yellow in proportion to the amount of indium sesquioxide used. This color appears to be developed by the interaction of indium sesquioxide as the glass is being made, because the adding of the indium sulfide (In_2S_3) to the glass-forming mixture does not produce the same result. The color is progressive, from light canary to dark tangerine-orange.

Indium is listed as number 49 in Mendeleeff's periodic table of elements. Reich and Richter are accredited with having discovered it in 1863, and because of the indigo blue lines in its spectrum, it was named "indium." Its isolation was made probably early in its history, but its commercial development was left until a few years ago. It was one of the elements that was supposed to be widely distributed in several kinds of ores, but always in minute quantities. While small amounts had previously been produced as residues, the author believes that he and his associates were the first to consider seriously its production from the ore.

The properties of this element are fairly well known. It is a white lustrous metal, very soft and ductile, and lighter than silver; it melts at 155° C. and is said to boil at about 1450° C. It has great surface stability at ordinary temperatures, but oxidizes and burns at temperatures above its melting point, especially if finely divided.

There are two known oxides of indium—the monoxide and the sesquioxide. The monoxide (InO) is black and probably not as stable as the other oxide since but two of the three valences of indium are satisfied. With further oxidation the monoxide becomes the sesquioxide. Indium sesquioxide (In_2O_3) is very stable and volatilizes without decomposition at 350° C. It has a specific gravity of 7.179 and a beautiful yellow color. Its solubility in fused alkali salts makes possible the new use in glass.

Indium when heated high enough in the presence of oxygen, will produce the sesquioxide easily. Another method of producing indium sesquioxide is as follows: The indium metal may be dissolved in a suitable acid such as hydrochloric and then precipitated by an alkali such as ammonium hydroxide. The indium hydroxide is filtered away from the solution, and, after drying, the hydroxide is burned to the yellow sesquioxide.

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THE TIME ELEMENT IN GLASS TESTING

By FRANK W. PRESTON

IT HAS been known for many years that glass, like most other materials, "fatigues" under load. A load or pressure which it will support for a moment may break it if sustained for an hour, and a load that is safe for an hour may be unsafe if sustained for a day or a week. The nature of this fatiguing process is at present unknown, but of its existence there is no doubt.

Thus it is useless to quote the "breaking strength" or "modulus of rupture" of glass unless the quoter gives at least an approximate idea of the duration of the test or of the rate of loading. This point has been stressed frequently enough by Mr. L. T. Sherwood among American glass men, and has been under investigation from time to time by Dr. Littleton at Corning, Mr. U. E. Bowes at Alton, by the present writer, and no doubt by others.

The existence of the phenomenon has been known for thirty or forty years at least and in France and elsewhere some preliminary skirmishes with the problem were undertaken a generation ago. A brief summary of the literature is given by K. H. Borchard in Glashutte No. 4, pages 47-48, January 22, 1934, under the title "Um die Festigkeit des Glases" ("On the Tensile Strength of Glass"), and a further report on recent experimental results is promised by the same author. I am indebted to Dr. Littleton and Miss Deneen of Corning for a preliminary translation of the January article.

Long-sustained loads occur in practice with several kinds of glassware. Bottles for use with beer, soda water (especially siphons) and so on, commonly described as "pressure ware" may have to sustain internal loads for long periods. Such pressure ware sometimes breaks, but in practice it is an exceedingly rare event for it to break solely as a result of internal pressure. The immediate cause of breakage is in nearly all cases something quite different, as is attested by the form of the fracture.

Skylights subjected to snow loads may be under long sustained stress, and any glass held in a warped position is in the same predicament. Boiler gage glasses are another example. In most cases the factor of safety is ample, but there is a lamentable lack of precise knowledge as to how far the time element enters in and reduces the apparent strength.

The present writer's experience is, that the rate of decrease of strength with time is not the same for all glasses, nor for all articles made of a given glass. Some bottles, for instance, seem to decline in strength, under internal pressure, much more rapidly than others. The reason at present is unknown, but there seems to be no doubt as to the facts.

It follows that the strength of glass cannot be given by a single figure as so many pounds per square inch. It will apparently be necessary to give the breaking strength for a load enduring one minute, and another figure which will permit an estimate of its strength if the load endures for a day or a month or a year. This figure may be the actual strength under a load enduring a given length of time, or, if a suitable formula can be found, it may be a "Constant" from which the strength under any duration of load can be roughly calculated.

It seems clear that instantaneous pressure tests, that is, pressure tests under continually increasing load, cannot be entirely satisfactory if the whole test is over in a few seconds. Such tests may serve to compare one day's output with that of some other day, but they give, in the absence of further experiments, very little information as to the strength of glass under sustained pressure. The last is what we generally want to know, though it is arguable that if we know that each day's product comes up to standard, it is good enough even in the absence of more precise information. In any case duration tests of some sort should be made from time to time; for, in the words of Mr. F. C. Flint, "it wouldn't hurt us to know more about the mechanical strength of our products."

In collaboration with the Glenshaw Glass Company, the staff of the present writer has developed a hydrostatic bottle testing machine of greater precision and convenience than previous types.* We hope to be able to present some conclusions drawn therefrom at a relatively early date, and we may also have further information from cross-bending tests of flat glass.

We might add that the necessity for quoting two figures for strength seems to be carrying out the general trend of glass technology. At one time we could quote an "annealing temperature", now it is necessary to give two "constants" (the Adams and Williamson constants). Similarly, the viscosity of two glasses must really give, in effect, the viscosity of each glass at a particular temperature and its rate of change with temperature. This is the most succinct form in which the data can be presented. We might list or graph the viscosity over a range of temperatures, and we might list the average breaking strength over a range of time-intervals. This is the most complete way, but the minimum requirements seem to be a listing of two figures, such as the strength at one minute and the strength at one month, or the strength at one minute and the rate of decrease of strength with duration of test.

*An advertisement of these machines appeared in The *Glass Industry* for September. A more complete account will be given at a later date.

ELECTED STEPHENS-ADAMSON PRESIDENT

L. S. Stephens has been elected to succeed D. B. Piersen as president of the Stephens-Adamson Mfg. Co., conveyor manufacturers of Aurora, Illinois. Mr. Piersen, one of the founders of the firm in 1901, was made chairman of the board upon the resignation of W. W. Stephens of Pasadena, California. Mr. L. S. Stephens, the new president, has been active in the firm since 1914. In 1921 he was made superintendent and in 1926 vice president in charge of production. There are no other changes in the firm—R. C. Pierce of Los Angeles is vice president and western manager, F. G. Adamson, also of Los Angeles, is treasurer, C. H. Adamson secretary, M. A. Kendall chief engineer and C. A. Krause of Aurora is assistant treasurer.

CONTAINER GROUP MEETS AT ATLANTIC CITY

Code, Production Allocation, and Statistical Position Chief Problems Discussed at Semi-Annual Meeting

THE fall meeting of the Glass Container Association was held at the Hotel Traymore, Atlantic City, September 19-21. About 125 were present, including most of the glass container manufacturers in this country and Canada. A complete change in program was effected this year. On the theory that too much time has hitherto been devoted to general discussion and not enough to problems of the individual groups, the open meetings were limited to a single session Thursday morning, and the customary banquet was omitted entirely. Wednesday was given over to Code problems, Thursday afternoon to group meetings, and Friday another closed meeting at which the principle of allocation of production was reaffirmed.

President Walter H. McClure called the general session to order. Mr. Chet Overmeyer asked for an explanation of certain features of the liquor bottle regulations that concern the manufacture of molds, following which Mr. Ackerman reviewed the Association's activities since the last meeting. Victor Hall presented his customary statistical report on production, shipments, and stocks on hand of the industry. Mr. Hall said in part:

Glass Container shipments have held up remarkably well during the last few months. For August the total General Line shipments were slightly over 2,600,000 gross and the total for all divisions including the West Coast was slightly over 3,000,000. This is only approximately 100,000 gross less than the high months of May and June. This showing for August is partly due to a greater volume of catsup bottle shipments than we have had during the last several years. It is believed that this volume will continue throughout the present month and will largely make up for some reduction in other lines. It is not believed, however, that our volume for the last quarter will equal the average of the first eight months, which for all lines was 2,950,000 gross per month.

The following explanation of the charts is given in the order in which they appear. On chart 1, the scale at the side indicates shipments in thousands of gross. The broken line at the top marked "Capacity" is the average monthly capacity for all companies in the Industry. Note that this figure stood at slightly over 5,600,000 gross per month. This is based on the total Industry having a capacity of 67,700,000 gross per year.

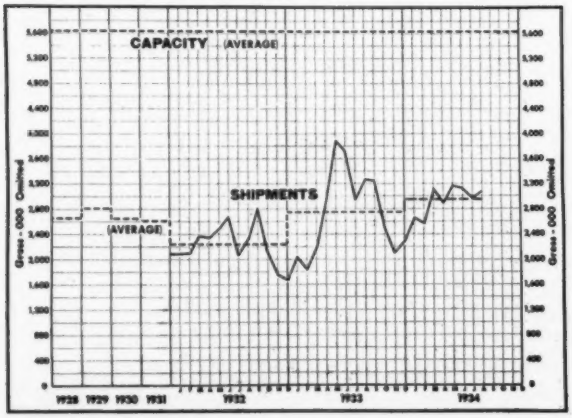
The irregular curve shows shipments of all classes of ware by months for the years 1932 and 1933 and for the first eight months of 1934. For the eight months of this year we see the effect of liquor ware replacing a part of the loss of beer bottle volume. Shipments of beer bottles during the eight months were nearly 3,000,000 gross less than a year ago but 2,000,000 of this loss was made up by shipments of liquor ware.

The dotted line showing the average shipments showed that from a low of 40 per cent of capacity for the year 1932 the Industry increased to better than 48 per cent to capacity for 1933 and 52 per cent for the eight months of this year. As stated at the start however, it is not anticipated that Industry will continue at this rate.

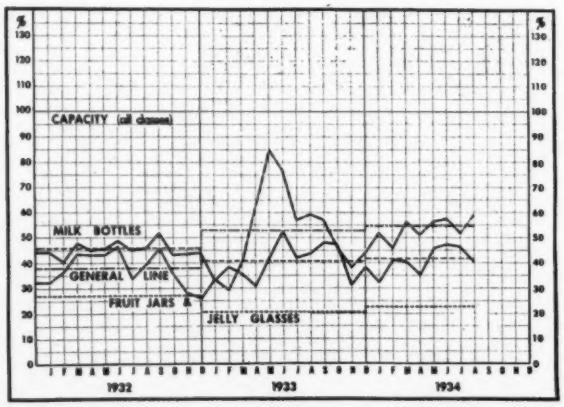
Chart 2 shows the relation of the volume of the three divisions East of the Rocky Mountains, namely, General Line, Milk Bottles and Fruit Jars and Jelly Glasses. In order to give effect to the differences in the average weight ware for each of these divisions the shipments have been converted to pounds by multiplying the gross shipped times the average weight bottle produced for each of the periods.

The line "100", then, has been taken as representing the capacity figure in pounds for each of these divisions.

Taking first the General Line, you will note that the average volume for 1932 represented 38 per cent to capacity, increased to slightly over 52 per cent during 1933 and to 54 per cent for the eight months of this year. Milk Bottles on the other hand averaged slightly over 45 per cent to capacity in 1932 and declined to about 41 per cent during 1933. For the eight months of this year very little improvement is shown over last year. For Fruit Jars and Jelly Glasses only the average is shown due to the fact that virtually all shipments are made during the second and third quarters of the year. The average for 1932 was only 27 per cent to capacity and this declined during 1933 to about 21 per cent. While the average for the eight months of this year was slightly



1. Total shipments compared with productive capacity.



2. Shipments in pounds by divisions, east of the Rockies.

better the lack of volume during the last quarter will reduce the average for the full year to slightly below 20 per cent of capacity.

Turning now to chart 3, while in the past we have used the Business Week Index of business activity, it was believed that this Standard Statistics Index is a better gauge of total industrial production. This index shown by the solid curve is compiled from 26 series of monthly figures.

For Glass Container shipments we have taken only the lines which follow to the greatest extent the trend of general business. The broken curve, then, represents the General Line Shipments exclusive of beer bottles and liquor ware.

It is interesting to note how closely the trend of our Glass Container shipments during 1931 and 1932 followed the index of industrial production. In almost every case where our Glass Container curve runs counter to the industrial production curve the deviation can be accounted for by some unusual volume in one or more of our Glass Container lines. For January 1933 a sharp up turn in our shipments was due to unusual volume in Medicinal and Toilet ware caused by an unusual amount of sickness. In December of last year the up turn in container shipments was due to the beginning of liquor ware shipments which were not reported separately until beginning with January 1934. For July and August of this year the better than seasonal performance shown by our shipments was due to a large measure by better volume in the Narrow Neck line.

In the final chart we have shown the volume for the eight months of 1929 as a base with the same period for each of the following years compared to it. For each bar the different classes are shown in their relation to the total bar. The percentage figure under the total gross for each class shows the relationship with the base period.

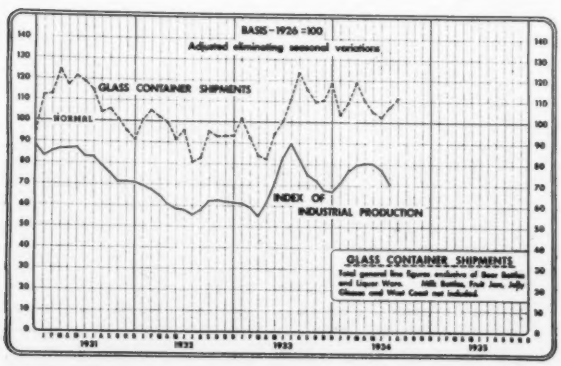
Mr. C. R. Stevenson, Manager of the Association called attention to the fact that the last quarter of this year would show a much higher payroll cost inasmuch as there have been many wage increases since the spring. In this connection he said that the glass container industry was one of the foremost to back the N. R. A.; its payroll had increased from 46.5 cents per gross produced in April 1933 to 67 cents per gross in March 1934. Probably the only industry in America that could point to a larger increase was textiles; but wages in the glass industry had never dropped to the very low textile level.

Referring to the general business situation, Mr. Stevenson observed that we are in the midst of two great opposing forces: those who sincerely believe the individualistic theory is best for the country in the long run, and others who want the government to control and operate everything. Even in the administration itself we find this division of thought. Until one or the other schools of opinion gains the ascendency, it is difficult to appraise the situation or to tell where we are going. When Congress next meets, pressure will be brought to bear to renew the N. R. A., expiring in June.

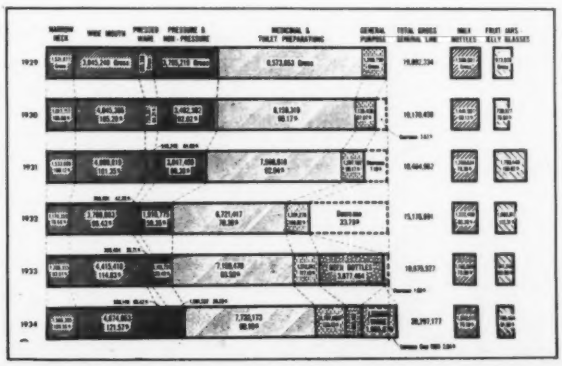
Mr. Stevenson feels that the key to the situation lies in the self government plan provided by N. R. A. This has never been permitted full play; for instance, it will never be possible to detect code violations unless inspection of individual manufacturer's books is permitted. Again, many codes are written forbidding the sale of goods below cost, but this is more honored in the breach than in the observance. Naturally, the more inefficient plants cannot produce and sell at the same price as the others. However, the glass industry avoided this problem by substituting a plan for sharing available business for the usual price fixing provision.

One of our major problems, that of unemployment, may never be satisfactorily solved by N.R.A. The majority of the unemployed are laborers, those who work with their hands, and the machinization of industry makes it impossible for them to find anything to do. Our system of relief is faulty in that it pays many who are on the relief rolls more money than those who do work. The solution is probably a still shorter work week—and, significantly enough, Mr. Stevenson reported that during the convention every Congressman had received a questionnaire from the American Federation of Labor asking his views on a 30 hour week bill.

Mr. Stevenson pointed to the dangers of unemployment insurance without self government. He postulated the erection of a new glass factory. Because the demand for glass containers is practically a constant, the new factory would not add to the total unemployment in the industry and the other plants would have to lay men off. Under an unemployment insurance plan, the individual members of the industry would find themselves in a bad way. Unemployment, concluded Mr. Stevenson, cannot be handled by a single company or a single industry. If industry is to handle the problem it must be given a large measure of self government. Otherwise unemployment insurance can only be handled as a national problem.



3. Comparison of glass container shipments with "Standard Statistics" index of industrial production.



4. Comparison of shipments by classes, east of the Rockies for the first eight months of 1930, 1931, 1932, 1933 and 1934.

FOREIGN TECHNICAL PAPERS

TRANSLATION By S. R. SCHOLES

EXAMINATION OF FLAT GLASS

"Distinguishing the Mode of Mode of Manufacture and Treatment of Flat Glass," by F. H. Zschacke, Technische Hochschule, Berlin. Condensed from Glastechn. Ber., July, 1934.

Under the name "Flat Glass" are included Plate, Window and Mirror glass. Before the introduction of machines, there were only two fundamentally different methods of making flat glass. One was by blowing cylinders (by mouth) which were later spread out into sheets; the other was by rolling the glass out into a thick plate, subsequently ground and polished. Since it was not possible to make window glass over a limited thickness, while on the other hand the rolling process could not make mirror glass under a certain strength, the thickness, aside from the optical properties of the surfaces, served to identify the source of the sheets.

These differences lessened when mechanical blowing or drawing increased the thickness of window glass, and improved rolling methods produced thinner plate. Today the relative thickness of sheets gives no clue to their source. There were four almost contemporary methods of making window glass developed: Lubbers, Fourcault, Colburn (Libbey-Owens) and Pittsburgh. The first has now disappeared, and the fourth is still being perfected.

The Lubbers process, semi-automatic, produced a very large blown cylinder by drawing a circular bait from a pot of glass, with continuous blowing. This cylinder was opened and flattened by hand, as in the mouth-blown process. Fourcault sheets are drawn from the tank vertically through a "debiteuse." The Pittsburgh Plate Glass Company's process requires no debiteuse, but is otherwise similar to the Fourcault. The Colburn process draws the sheet vertically, then bends it to a horizontal direction for continuous travel through the annealing chamber. Plate glass for mirrors, or polished plate, is rolled by one movable roller or several fixed ones. Rough and ornamental plate is produced by special rolls, and is not subsequently ground or polished.

Previous Means of Identifying Varieties. Differentiation of sheets made by these different processes is possible by these means: 1. Flattened window glass always shows, upon looking through it, a more or less irregularly distorted view, while drawn window glass in unpolished condition gives a somewhat regularly distorted picture. This so called "optic" of window glass arises from the fact that the surface is not optically flat, and slight inequalities in thickness and slight warpings produce prismatic refractions. These effects are irregular in flattened glass, because of its mode of manufacture, while in drawn sheets they appear as parallel stripes or waves in the direction of drawing. There are also irregular waves in drawn sheet, best viewed by reflected light. No examples are given, but reference is made to the literature of the subject.

This distortion of vision is easily established when a distant object is viewed through the glass and the sheet or the observer's head is moved. The waviness of surface is best seen by reflected light. It is most apparent in Fourcault glass, weaker in Libbey-Owens, and least apparent in Pittsburgh glass, so far as the writer's observations extend.

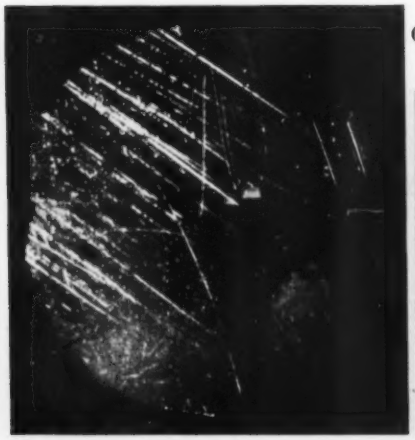
2. Rough-rolled and ornamented glasses are easily recognized by the appearance of the surface.

3. Polished plate glass possesses in general a perfectly plane surface, and shows no distortion of vision.

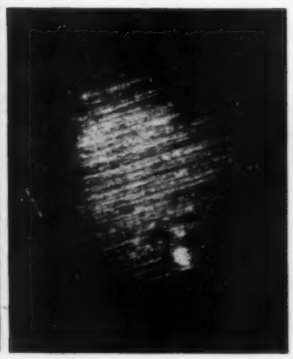
Positive identification of only the rough and ornamented sheets is possible, because well-made window glass may approximate in optical surface that of polished plate, especially in small pieces. And when the sheets have been ground and polished, the eye cannot detect whether they were originally rolled or drawn.

The Etching Procedure and its Effects. A procedure was developed which established even on small pieces of glass: (1) whether the glass had undergone a surface treatment — grinding and polishing; (2) when the surface had not been subsequently treated, by which process the sheets were made; (3) when the surfaces were treated, whether the glass had been rolled or machine drawn.

To answer the first two questions, the cleaned glass is etched in a solution of water 100, hydrofluoric acid 10, and concentrated sulfuric acid 5, with a little

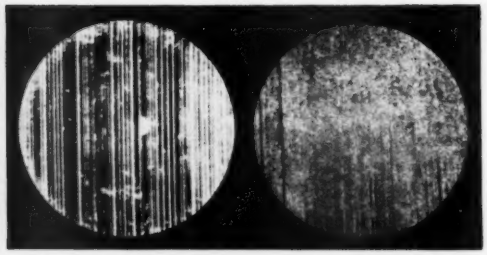


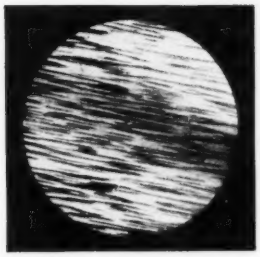
(left) Fig. 1. Mouth-blown window glass, etched.



(left) Fig. 2. Lubbers window glass, etched.
(below) Fig. 3. Fourcault glass.

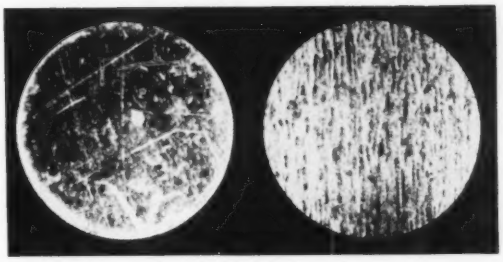
Etched Weathered





(left) Fig. 4. Libbey-Owens Glass, etched.

(right) Fig. 5. Ground and polished mirror glass. On the left, weak etching; on the right, strong etching.



potassium bichromate. The treatment lasts 10 to 60 minutes, as a rule, but may at times require 24 hours. The glass is then rinsed and dried. Several strips 2 cm. wide are treated for different times. The dried glass is viewed transparently against a bright (sky) background, then by reflected light against a dark background, and the following phenomena appear:

1. Flattened glass: The two faces etch differently. The side against the stone when the cylinder was opened is more roughly etched than the blown side, and is regularly "matt," with numerous pin holes and blank spots. A few scratches are emphasized by the etching. The glossy side (Fig. 1) shows after etching a striped appearance, the traces of the strokes of the wooden tool used in flattening. This is apparently a chemical phenomenon, depending upon the grain of the wood and the temperature of the glass when stroked. Too long a time of etching causes disappearance of these etch figures.

2. Lubbers glass gives a similar picture to that of mouth-blown. The stone side is less matt, with fewer scratches and blank spots. The striped effect on the glossy side is more strongly developed—probably because a large tool is used in flattening. Few specimens were available. (Fig. 2).

3. In Fourcault glass the etched structure (Fig. 3, left) develops in 5 minutes. This consists of countless fine lines, running endlessly in the direction of drawing, easily visible by transmitted or reflected light. It persists on long etching. The lines appear on both sides of the sheet and are slightly fainter on the so called cold side. They are a debiteuse effect, not formed on sheets from a new debiteuse, but appearing after 2 hours. Lines may be observed on the sheet as it leaves the debiteuse, during the drawing. These are parallel and separated by a distance corresponding to that between the strongest lines of the etched structure. They may be related to clay substance dissolved from the debiteuse, which may cause variations in reaction of the glass with the acid—a view supported by the achievement of a similar effect by long exposure of the sheet to fumes of hydrochloric acid.

Moreover, weathered Fourcault glass shows the same surface structure (Fig. 3, right). This is iridescent, with a deposit that can be partially washed away, leaving the striping. If the glass is heated to softening before etching, these stripes scarcely appear.

4. The Pittsburgh glass is the only flat glass yielding no surface structure after etching, even continued for several days.

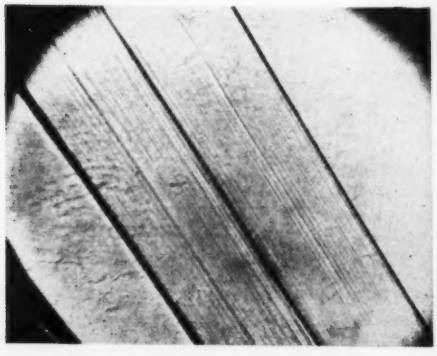
5. The Libbey-Owens glass (Fig. 4) shows after etching an irregular grouping of elongated, dark flecks, lying parallel in a matt ground, when viewed by reflected light over a dark background. These are all on the "tank" side of the sheet. The leer side is unchanged. The etching requires from an hour to a day, and the structure persists up to two weeks' treatment, on thick specimens. Silvering, without etching, brings out the same effect.

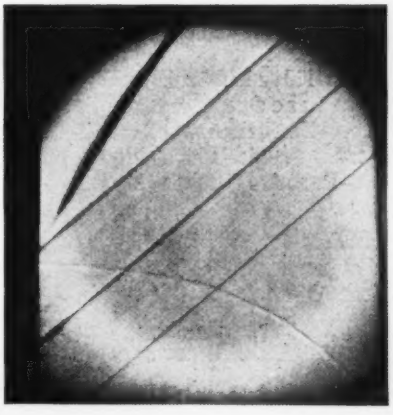
This surface structure is attributed to a film of sulphate formed by reaction of the furnace gases with the glass surface. The film is stretched by the drawing process, like oil on flowing water, and tears as it stretches. It varies in thickness and is sometimes easily removed by polishing, but sometimes the effect persists. (In contrast, the etch lines on Fourcault glass are deeper, and a more

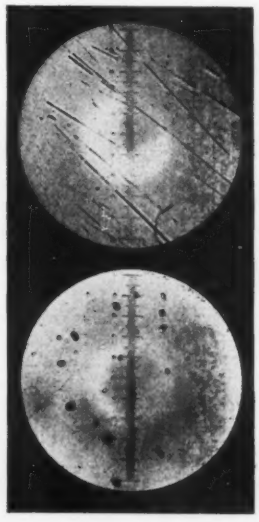
(Extreme right) Fig. 6. Ground and polished mirror glass. Upper view shows "chain of pearls" structure; lower view, crater structure.

(Extreme left) Fig. 7. Cords in rolled glass.

(Center) Fig. 8. Cords in drawn flat glass.







severe grinding and polishing are necessary to prevent their appearance on later etching).

If Libbey-Owens glass is heated to softening before etching, no surface structure appears.

6. Ground and polished glass upon weak etching—about five minutes—shows on a blank surface a few long, criss-cross lines, probably grinding marks obscured by polishing (Fig. 5, left). Continuation of etching for 15 minutes brings out a very fine network of lines (Fig. 5, right) in some samples; other glasses show only a sort of very fine satiny surface.

Under the microscope two types of pictures appear: a chain-of-pearls structure, as in Fig. 6, right; and a crater-structure, Fig. 6, left. Longer etching changes these appearances, deepening the depression causing the crater structure.

Cords in drawn and rolled glass show in the pictures seen in Fig. 7 and Fig. 8.

ALFRED EXHIBITS GLASS-BLOWING AT N. Y. STATE FAIR

Part of the exhibit of the N. Y. State College of Ceramics at the State Fair at Syracuse, Sept. 1-8, was a demonstration of off-hand glassworking. The artisan was Frank P. Schroeder, of the Steuben Division, Corning Glass Works, who made a variety of pieces—goblets, comports, candlesticks, and vases—to the wonderment of crowds as large as were present at any of the Fair's attractions.

The glass, a deep blue in color, was made at the Alfred laboratory, and the cullet was shipped to Syracuse and re-melted in a tiny circular tank of 150 lb. capacity. There being no gas-supply on the grounds, this furnace and the "glory-hole" were fired with "Pyrofax" drawn from a 4-cylinder battery outdoors. No annealing oven was provided, and the mortality among the pieces made was unanimous—to the vocal distress of many of the thousands who came to watch the skilful manipulations of Mr. Schroeder.

CONFERENCE ON GLASS PROBLEMS

Plans for the Conference on Glass Problems to be held at the Department of Ceramic Engineering, University of Illinois, Urbana, Illinois, November 2 and 3 are being perfected. The tentative program includes papers on: "The Use of Glass Cullet," "Some Problems and Perplexities in the Glass Industry," "Observations on Heating a New Tank," "Batch Constituents and Their Effect on the Durability of Glass," "Fuel Oil versus Producer Gas in Glass Melting," "Practical Tank Operation," "Changes in the Elastic Properties of Glass as Affected by Temperature," and others.

Those expecting to attend the meeting should send in requests for room reservations in advance since the Army-University of Illinois football game on Saturday, November 3, will bring a large crowd of visitors into town.

A CORRECTION

In the August 1934 issue of *The Glass Industry*, the address of Dr. Willi M. Cohn was incorrectly given as "Alameda, Calif." His correct address is 1682 Scenic Ave., Berkeley, California.

BOOK REVIEW

Experimental Researches and Reports. Vol. xvl, 1933. Published by the Department of Glass Technology, The University, Sheffield. P.p. 180, price 7/6.

This volume is a collection of sixteen papers, researches and reports which have been contributed in the last year (1933) to the following journals: Journal of the Society of Glass Technology; Glastechnische Berichte; Glass Review. The papers include the following subjects:

1. Note on the Formation of Sodium Sulphate in Glass Furnaces and some Defects arising therefrom.
2. The Rate of Reaction between Silica and Sodium Carbonate at Different Temperatures and the Process of Vitrification.
3. Specifications for Raw Materials in the Glass Industry.
4. A Note on the Vapor Tension of BaO, SrO, and CaO and their Mixtures deduced from Measurements of the Rates of Evaporation.
5. A Study of the Volatilisation from Potassium Oxide-Silica Glasses.
6. The Behaviour of Glass when Slowly Heated with Special Reference to the Thermal Expansion.
7. On the Evaporation and Diffusion of Volatile Materials into an Inert Gas Stream.
8. Fuels and Furnaces for Glassmaking.
9. Refractory Materials for Glass Furnaces, 1932-33.
10. Progress in Mechanical Methods in the Glass Industry.
11. Chemical Analysis as Applied to Glasses and Silicates, and to Raw Materials for Glassmaking.
12. Progress in the Investigation of Chemical Properties and in the Chemical Testing of Glass.
13. The Physical Properties of Glass and their Application.

CATALOGS RECEIVED

Rockwood Short-center Flat Belt Drive. Bulletins Nos. 17 and 18 issued by The Rockwood Manufacturing Company, Indianapolis, Ind., describe new installations and contain engineering articles treating with some phase of machine and motor operation and maintenance.

Lubrication. September, 1934. The Texas Company, New York City. This issue is devoted to the trend toward automatic lubrication for rock crushing machines including an article on screen design and lubrication.

NEW PUBLICATIONS

Ceramic Forum. Vol. 1, No. 1, September, 1934. Published at 209 Fourth Ave., Pittsburgh, Pa. A newspaper of—and for—the ceramic industry. Its prime function is the recording of interesting activities of individuals and organizations within the industry.

Southern Alkali. The Southern Alkali Corporation, Corpus Christi, Texas. A special brochure with excellent typography and layout to announce the opening of their new plant. It contains a discussion of the markets and location of the new plant and its facilities for producing soda ash, caustic soda, liquid caustic soda, modified sodas and caustic ash.

EQUIPMENT AND SUPPLIES

SOUTHERN ALKALI ANNOUNCES OPENING OF NEW PLANT

The Southern Alkali Corporation, new joint subsidiary of the Pittsburgh Plate Glass Co., and the American Cyanamid Co., has announced the opening of a new alkali plant at Corpus Christi, Texas. After spending some three years in planning and construction, the Corporation believes it has a plant with unsurpassed production and distribution facilities. Three railroad trunk lines bring it into contact with Gulf Coast and Mid-continent concerns. It has the further advantage of location on tidewater, with its own port and turning basin, and a new 30 foot channel that has just been dredged enables ocean-going vessels to dock at the plant site.

New plant of Southern Alkali Co. at Corpus Christi, Texas.

Materials for the manufacture of alkalies are within easy reach. These include salt, limestone, coke, oyster shells and power. The salt is piped from Company wells 60 miles away by natural gravity flow, and stored in an open reservoir. Coke and limestone are shipped from nearby Southern points. Oyster shells are obtainable in abundance from the large deposits in Nueces Bay. Power is available from natural gas, with Company wells located only six miles away. This fuel supply is said to produce power at a cost below that of the cheapest coal.

Southern Alkali expects to manufacture and distribute the following alkali products from the new plant: soda ash, caustic soda, liquid caustic soda, modified sodas and caustic ash. Alkali buyers are invited to submit their production and handling problems to a trained technical staff.

NORTHERN BLOWER CO. REPORTS

Increasing interest is being shown in dust and fume recovery, reports Mr. M. A. Eiben, president of The Northern Blower Co., Cleveland, Ohio. Among the larger orders secured by him on his recent business trip are, a complete fume-recovery system for use on the blast furnaces at the Bunting Brass Co., Toledo, Ohio, and a considerable dust-recovery plant at the Southern Alkali Co., Corpus Christi, Texas. The Northern Blower Co. is now installing soot-conveying equipment for use in connection with the gas producers at the Owens-Illinois Glass Co. "Business in the offing looks good," Mr. Eiben states.

H-E BUILDING READY DECEMBER 1

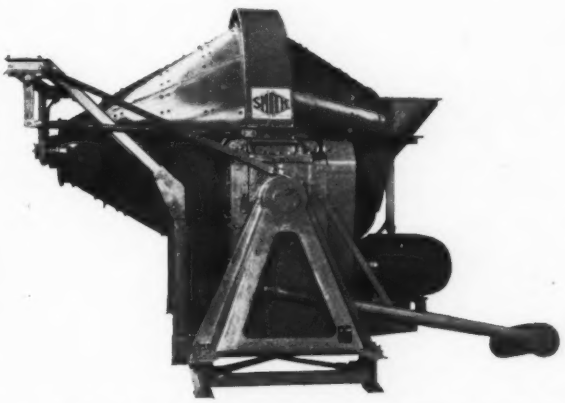
Work on the new $70,000 addition to the Hartford-Empire Company's plant is rapidly nearing completion and it is expected that the building will be ready for occupancy before December 1. Built of brick, steel and glass, it will furnish much needed office space and conference rooms, as well as accommodations for the engineering and drafting departments. A large two-story fire proof vault is one of the features of the new building.

T. L. SMITH CO. INSTALLS BIG MIXER

The T. L. Smith Company, Milwaukee, Wis., have recently installed a 56 cubic foot tilting mixer in the Minnesota Mining & Manufacturing Company's plant at Wausau, Wisconsin.

In the mixer as illustrated, the feed chute is equipped with an atomizer to settle dust and introduce liquid into the drum. As the materials are dumped into the drum, suction on the discharge side provides for the escape of air.

An electric motor equipped with speed reducer and solenoid control tilts the drum, while tight fitting sealing doors prevent the escape of dust or vapor from its interior. The doors open automatically and all moving parts of the mixer run on anti-friction bearings.



Smith 56 Cubic Foot Tilting Mixer With Automatic Sealing Doors.

Special features include the double cone drum with end-to-center mixing action—central gear ring with balance batch at center—easy, rapid flow, fully controlled discharge—all of which are said to give efficient, speedy, economical operation for glass batch and quartz mixing.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per 100 lb.		5.50	...
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	...	Po. or Gr. .25 / Cry. .25½
Alcohol, denatured	gal.	...	...
Aluminum hydrate ($Al(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.05¼	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.09
Antimony sulphide (Sb_2S_3)	lb.	...	.08
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.04	.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%. 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.05¼	.05¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.08¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.02	.02¼-.02½
Powdered	In bags, lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3) granulated	In bags, lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—	lb.	...	.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	...	.06
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	...	.215-.25
Cobalt oxide (Co_2O_3)			
In bbls	lb	..	1.25
In 10 lb. tins	lb.	...	1.35
Copper oxide			
Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.17-.19
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.085	.09
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.40
Feldspar—			
40 mesh	ton	10.50-12.75	
20 mesh	ton	10.00-12.25	
Granular	ton	10.75-13.00	
Semi-granular	ton	10.00-12.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	30.00-35.00	...
In bags	ton	33.00-36.50	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	..
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead)	lb.	.062	...
In 5 Ton lots	lb.	...	.0675
Less than 5 Tons	lb.	...	.0725

		Carlots	Less Carlots
Lepidolite	ton	45.00	...
Litharge (PbO)	lb.	.052	...
In 5 Ton lots	lb.	...	.0575
Less than 5 Tons	lb.	...	.0625
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	...
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.03
Manganese, Black Oxide			
In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	4.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.08½
Powdered	lb.	...	.09½
Potassium carbonate	lb.	.0825	.0875
Calcined (K_2CO_3) 96-98%	lb.	.07¾	.0875
Hydrated 80-85%	lb.	.07¾	.0775
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17-.18
Rare earth hydrate			
100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.		...	.12½
Rouge	lb.	...	Po. or Gr. .13½ / Cry.
Rutile (TiO_2) powdered, 95%	lb.	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se)	lb.	...	1.80-2.00
Silver nitrate ($AgNO_3$) (100 oz. bot.)	per oz.	...	.35¼
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06⅛	.06¾
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.05	.05¼
Sodium hydrate (NaOH) (caustic soda)			
Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97%			
Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.55-1.60
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.45	3.70 4.05
Flowers, in bags	Per 100 lb.	3.10	3.35-3.65
Flour, heavy, in 350 lb. bbls.	Per 100 lb.	2.25	2.50
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.385
Tin oxide (SnO_2) in bbls.	lb.	...	.54-.58
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.60
Zinc oxide (ZnO)			
American process, Bags	lb.	.065	.0675
White Seal, 150 lb. bbls.	lb.	.10⅜	.10⅞
Green Seal bags	lb.	.09⅜	.09⅝
Red Seal, bags	lb.	.08⅜	.08⅝
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04 .05

THE DURABILITY OF GLASS

—a Bibliography of the Important Literature—Part II.

IV. Relation of Composition and Durability

Disintegration of Glasses of Different Compositions. E. Zschimmer (Chem. Zeitung, 1901, 25, 780).
Results of experiments on the weathering of various composition optical glasses.

The Physical Properties of Glasses as a Function of the Chemical Composition. E. Zschimmer (Zeitsch. Elektrochem., 1905, 11, 629).
Discussion of factors influencing the durability of glass.

Classification of Lime-Alkali Glasses According to the Tschenschner Formula. J. Koerner (Sprechsaal, 1915, 48, 333).
Experimental evidence showed that the original formula

$$Z=3\left(\frac{x^2}{y}+4\right)$$

or if lime is expressed as unity $Z=3(x^2+1)$ holds good for pure calcium, sodium glasses but not for calcium, potassium glasses. For these glasses a better formula is $Z=4(x^2+1)$. Two additional modified formulae are given:

(1). for preponderating soda

$$Z=\left(3+\frac{x\,K}{x}\right)(x^2+1)$$

(2). for preponderating potassium

$$Z=\left(3+\frac{x\,Na}{x}\right)(x^2+1)$$

$x\,K$=number of molecules of K
$x\,Na$=number of molecules of Na

Notes on Barium Glasses. A. E. Williams and S. E. Fox (Trans. Amer. Cer. Soc., 1916, 18, 315).

Durability of Heavy Lead, Potassium Glass. V. D. Canwood, W. E. S. Turner, D. Webb, (Jour. Soc. Glass Tech., 1918, 2, 33).
Action of various chemicals on lead, potassium glass studied. Increase in lead content caused a rapid increase in resistance towards water but a decrease in resistance towards acids and alkalies.

Durability of Lime, Soda Glasses. J. D. Canwood, J. R. Clarke, C. M. M. Muirhead, W. E. S. Turner (J. Soc. Glass Tech., 1919, 3, 228).
A series of lime, soda glasses were tested for their resistance towards various chemicals. Results and compositions of glasses are given. Mechanics of attack is discussed.

The Comparative Effects of Sodium and Potassium in Lead Glass. F. H. Hodkin and W. E. S. Turner (J. Soc. Glass Tech., 1920, 4, 13, 120).
A study of the resistance of various composition tableware glasses towards water, steam, and hydrochloric acid. Compositions are given.

The Development of Various Types of Glasses. C. J. Peddle (J. Soc. of Glass Tech., 1920, 4, 3, 20, 46, 59, 71, 299, 310, 320, 330; 1921, 5, 72, 195, 201, 212, 220, 228, 256).
Gives methods for determining the solubility and weathering of optical glasses; results of tests on various composition optical glasses; influence of various constitutive compounds on solubility and weathering.

On the study of Zulkowski's Theory. W. L. Baille (J. Soc. Glass Tech., 1922, 6, 68).
Gives results of the application of Zulkowski's theory to optical glasses of known composition, the development of a modified theory and a discussion of durability.

On the Durability of Magnesia Containing Glasses. V. Dimbleby, C. M. M. Muirhead and W. E. S. Turner. (J. Soc. Glass Tech., 1922, 6, 101).
Results of durability tests on magnesia soda glasses of known composition and a comparison with the durability of calcium soda glasses.

The "Spiegel" Group of Glasses. E. Zschimmer (Sprechsaal, 1923, 56, 239, 250, 262).
The chemical stability of sodium, potassium, calcium, silica glasses were studied and classified.

Synopsis of the Resistance of the Alkali Calcium Glasses. G. Keppeler (Sprechsaal, 1924, 57, 617).
A discussion of existing data.

Note on Keppeler's Survey of the Resistance of Alkali Lime Glasses. E. Zschimmer (Sprechsaal, 1924, 57, 678).

Note on the Durability of Lead Glasses. G. Keppeler (Sprechsaal, 1924, 57, 573).

Lead Glass and the Glass Formula. O. Knapp (Sprechsaal, 1924, 57, 512).
A graphical study of glass compositions based on Tschenschner's formula.

Resista Glass as a Material for Laboratory Apparatus. (Sprechsaal, 1924, 57, 457).

A New Bottle Glass. D. W. Schmidt (Ker. Rundschau., 1924, 32, 408).
Results of durability tests on a glass containing 15 per cent alumina.

On the Influence of Titania (on Durability). A. K. Sheen, W. E. S. Turner. (J. Soc. Glass Tech., 1924, 8, 187).
The action of water and caustic alkali on a series of glasses containing titania was studied.

The Use of Boric Oxide in Glass Making. W. E. S. Turner (J. Amer. Cer. Soc., 1924, 7, 313).
Results of durability tests on a series of B_2O_3 containing glasses of known composition.

Keppeler's Rule for Lead Glasses. O. Knapp. (Sprechsaal, 1925, 58, 110).

On the "Lead Glass Laws". E. Zschimmer. (Sprechsaal, 1925, 58, 576).

On the Influence of Boric Oxide (on Durability). F. Winks and W. E. S. Turner. (J. Soc. Glass Tech., 1926, 10, 102).
Discussion of previous work, results of the action of various reagents on glasses of known composition. Analysis of extracted material.

The Durability of Glass and the Peddle Generalisation. O. Knapp (J. Soc. Glass Tech., 1926, 10, 294).
A discussion of Peddle's generalisation and Peddle's method of determining durability.

The Durability of Glasses Containing Zinc. W. L. Baille. (J. Soc. Glass Tech., 1926, 10, 299).
Discussion of Mauri's work with the autoclave.

On the Chemical Composition and the Chemical Resistance of Glass. (Part I) V. Dimbleby and W. E. S. Turner. (J. Soc. Glass Tech., 1926, 10, 304).
A review of previous work, discussion of various durability tests, results and comparisons of the durability of various glasses of known composition and a study of the application of the results to commercial glasses.

On the Properties of Lead Glass as a Function of their Composition. H. Karmans. (Sprechsaal, 1926, 59, 725, 747, 768).

Glass (Resistance to Chemical Attack, etc.) H. Kubl (Glashutte, 1926, 56, 743 et. seq.; 1927, 57, 3 et. seq.)
The value of different oxides in producing resistant glass is discussed.

Influence of Zinc Oxide on the Chemical Resistance of Glass. M. A. Besborodow. (Keram. Rundschau, 1927, 35, 743).
Discussion of work by Mauri and Baille on zinc glasses. Results of authors' work on zinc glasses.

The Durability of Soda-Lime-Silica Glasses. G. Keppeler and H. Ippach. (Sprechsaal, 1927, 60, 239, 261, 281, 298).
The action of water on glasses of various compositions was studied by the following method: 900-2500 mesh glass powder at 100°C in water. Total extract and/or alkali content of extract determined. Curves of equal durability were constructed. (Isolytes).

On the Composition of Lead Glasses. O. Knapp. (Sprechsaal, 1927, 60, 242.)
Discussion of the durability of lead glasses.

The Composition of Lead Glasses. O. Knapp. (Sprechsaal, 1927, 60, 226).

On the Chemical Composition and the Chemical Resistance of Glass. Part II. Iron Oxide Glasses. V. Dimbleby and W. E. S. Turner. (J. Soc. Glass Tech., 1928, 12, 52).
Results of tests on known composition glasses containing iron and a comparison with the results for other composition glasses.

On the Durability of Magnesia-containing Glasses. M. A. Besborodow. (Keram. Rundschau., 1928, 36, 365).
Action of various reagents on glass of known compositions were studied.

On the Relation of the Water Durability and Chemical Composition. J. Enss (Glastech. Ber., 1928, 5, 449).
A discussion of various factors such as grain size, annealing, time and temperature on the durability by the powder method. The following method was used: $18 \times \frac{\text{Sp. Gr.}}{2.54}$ grams of glass (2.54=standard gravity) treated with 100 cc. of water at 100°C. for 7 hrs. using a reflux. Weight of extracted material used as a measure of the resistance. 83 glasses of various known composition tested and the results compared.

Discussion of the Peddle Generalisation. K. Tabata, S. Moriyasn, K. Yegami (J. Soc. Chem. Ind., Japan. 1928, 31, 239 B).

On the Effect of Boric Oxide on Bottle Glass. V. Dimbleby, M. Parkin, W. E. S. Turner, F. Winks. (J. Soc. Glass Tech., 1929, 13, 248 and 259).
Results of durability tests on glasses containing small amounts of boric oxide.

On the Durability of Soda-Calcium-Silica Glasses. W. Mollen and E. Zschimmer (Sprechsaal, 1929, 62, 38, 57, 79, 94, 115, 133, 150).
Discussion of previous work. Time factor discussed. Glasses tested by powder method and by a rod method using a special apparatus. Description of procedure and results of tests on various composition glasses. Curves (Isokals) constructed.

The Alkali-Lime-Silica Glasses. (Durability) G. Keppeler and K. Bohmert. (Keram. Rundschau, 1930, 38, 663, 697, 711, 738, 787).
Using the methods of Keppeler and Ippach potassium, calcium, silica and mixed alkali glasses were studied.

Influence of Manganese on Durability of Glass. A. A. Childs, V. Dimbleby, F. Winks, and W. E. S. Turner. (J. Soc. Glass Tech. 1931, 15, 58, 172).
Results of durability tests on glasses containing manganese.

Solubility of Glasses in Water in Relation to their Composition. S. Moriyasu. (J. Soc. Chem. Ind., Japan 1931, 34, 314B, 358).

Bottle Glass and Durability. J. Keppeler and R. Maenicke. (Sprechsaal, 1931, 64, 7, 28, 46, 65).
Durabilities of a number of German bottle glasses of known composition were tested. Results and comparisons tabulated.

The Influence of Zirconia on the Durability of Heavy Baryta Crown Glasses. W. G. Vomot and A. A. Appen. (Optic a. Mech. Ind., U.S.R.R., 1932, No. 12, 8).
Results of experiments on an attempt to increase the durability of heavy baryta crowns by additions of zirconia for silica.

Solubility of Lead Glass in Relation to its Alkali Content. O. Knapp. (J. Soc. Chem. Ind., Japan, 1932, 35, 520B).
Comparison of results of various investigators and a discussion of the further work required on the subject.

V. General Information

A Bibliographical Contribution Towards the Study of the Durability of Glass. W. E. S. Turner. (J. Soc. Glass Tech., 1917, 1, 213).
A bibliography covering up to 1916.

Note on the Solubility of Clay in Glass. J. H. Davidson and W. E. S. Turner. (J. Soc. Glass Tech., 1918, 2, 280).
Results of the action of water on glass of various grain size.

Adsorption of Metals from Drinking Water by Glass. K. Scheringer. (Pharm. Wukblad, 1919, 56, 8).

The Selection of Glass for the Manufacture of Ampoles. G. E. Ewe, (J. Franklin Inst., 1920, 189, 649).

Some Relations of Compositions to Solubility of Enamels in Acids. H. F. Staley. (J. Amer. Cer. Soc., 1921, 4, 703).

The Manufacture of Optical Glass. C. J. Peddle. (Trans. Opt. Soc., 1921-22, 23, 103).
Contains the results of investigations on the influence of composition on durability and weathering of optical glass.

Solubility and Decomposition in Complex Systems. G. W. Morey. (J. Soc. Glass Tech., 1922, 6, 20).
A discussion of the systems, H20-K2O-CrO3 and H2O-K2O-S:02.

Durability tests represent rates of decomposition and are not tests of true solubility. Contains a discussion of various factors in testing durability.

Estimation of the Surface Area of Glass Powder. H. Wolff. (Zeitsch. angrew. Chem., 1923, 23, 138).

The Relative Action of Acids on Enamels. E. P. Poste. (J. Amer. Cer. Soc., 1923, 6, 689).

The Hydration of Natural and Artificial Glasses. G. Schott and G. Luick. (Kolloid-Zeitsch., 1924, 34, 113).

Chemical Durability of Glass. G. Keppeler. (Glastech. Ber., 1927, 5, 97).

Weathering and Durability of Glass. K. Veda. (Rep. Asahi Glass Co., Res. Lab., 1927, 17, 391).
Annealed glass more durable on the surface than on interior. Results of dimming tests and boiling water tests.

Improving (the Chemical Durability of) Hollow Ware. G. Keppeler, (Ger. Pat. No. 512,904, Mar. 3rd, 1927).

Substances capable of developing gases which combine with alkali on heating were introduced into the already formed ware.

The Solubility of Glass. W. Meyer. (Chem. Ztg., 1928, 52, 151).
Results of the extraction of selenium from glass by ether and alcohol after various periods of time.

Annealing and Alkali Extraction Values of Chemical Apparatus Glass. H. Lober. (Sprechsaal, 1928, 6; 160 and 181).
The durability of annealed and unannealed glasses were compared by Mylius surface method and Fisher and Tepohl powder method.

The Influence of Carbon Dioxide Under Pressure on Glass. O. K. Botvinkin. (J. Russ. Phys. Chem. Soc., 1928, 60, 221).

Research on Bottle Glasses. G. Keppeler. (Glastech. Ber., 1929-30, 8, 65).
The action of beer on bottle glass studied.

The Solubility of Feldspars in Water. C. W. Parmalee and A. J. Monack. (J. Amer. Cer. Soc., 1930, 9, 386).

The Influence of Durability of Containers on Decomposition of Hydrogen Peroxide. Glashutte, 1930, 60, 39).

Acid Durability of Over-glaze Colors. R. Ricke and L. Mauve. (Ber. Deut. Keram. Ges., 1930, 11, 487).

The Action of Alkaline Washing Solutions on the Durability of Over-Glaze Colors. E. Killias. (Ber. Deut., Keram. Ges., 1930, 11, 602).

Surface Changes and Deposits on Glass. F. H. Zschacke. (Glashutte, 1930, 60, 791).
A discussion of lehr bloom.

Some Reflections on Lehr Bloom. S. Guss. (Glashutte, 1930, 60, 935 & 954; 1931, 61, 8).

Trustworthy Ampoles. W. Obst. (Glas und App., 1930, 11, 203).
A discussion of the importance of durable glass for ampoles.

The Solubility of Strained Glass in Relationship to the Distance from the Surface S. I. Jofe. (Trans. State Inst. Test Bldg. Mat. and Glass., U. S. S. R., No. 29, 1930).

Methods of Testing the Acid Resistance of Enamel Colors. T. Eisenlohr. (Keram. Rundschau., 1931, 39, 9).

The Durability of Glass. A. Granger. (Ceram. et Ver., 1931, 51, 203, 253, 317, 377).
A series of four papers giving a detailed historical review of methods of measuring durability and theories of durability.

Contribution on the Durability of the Alkali-Lime Glasses. O. Knapp. (Keram. Rundschau. 1931, 39, 126).
A review of results of various German workers.

The Influence of Surface Treatment on Durability of Glass Surfaces. M. V. Hirschberg and F. H. Zschacke. (Sprechsaal, 1931, 64, 790).
The effect of certain surfaces treatments such as iridescence and lustres on the durability were studied.

The Solubility of Water in Granite. Magnas R. W. Gorauson. (Amer. J. Sci., 1931, 22, 481).

The Quality of Chemical Glassware. H. Fisher and F. Friedrichs. (Glas und App., 1931, 12, 151).
A discussion of the use of hydrolytic classification as a means of determining the suitability of glassware for chemical purposes.

Decomposition and Disintegration of Glass. G. V. McCauley and C. D. Spencer. (Ceram. Ind., 1932, 18, 20).
A review of the subject.

The Stability of Glass. A. Thuermer. (Rev. Belge. Ind., Ver., 1933, 4, 98-100).
From the results of various tests it was concluded that durability not only depends upon chemical composition but also upon the method of manufacture and the previous thermal history.

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